SWEEP

SOIL AND WATER

ENVIRONMENTAL

ENHANCEMENT PROGRAM

PAMPA

PROGRAMME D'AMELIORATION

DU MILIEU PEDOLOGIQUE

ET AQUATIQUE

Canada

Ontario

SWEEP

is a $30 million federal-provincial agreement, announced May 8, 1986, designed to improve soil and water quality in southwestern Ontario over the next five years.

PURPOSES

There are two interrelated purposes to the program; first, to reduce phosphorus loadings in the Lake Erie basin from cropland run-off; and second, to improve the productivity of southwestern Ontario agriculture by reducing or arresting soil erosion that contributes to water pollution.

BACKGROUND

The Canada-U.S. Great Lakes Water Quality Agreement called for phosphorus reductions in the Lake Erie basin of 2000 tonnes per year. SWEEP is part of the Canadian agreement, calling for reductions of 300 tonnes per year — 200 from croplands and 100 from industrial and municipal sources.

PAMPA

est une entente fédérale-provinciale de 30 millions de dollars, annoncée le 8 mai 1986, et destinée à améliorer la qualité du sol et de l'eau dans le Sud-ouest de l'Ontario.

SES BUTS

Les deux buts de PAMPA sont: en premier lieu de réduire de 200 tonnes par an d'ici 1990 le déversement dans le lac Erie de phosphore provenant des terres agricoles, et de maintenir ou d'accroître la productivité agricole du Sud-ouest de l'Ontario, en réduisant ou en empêchant l'érosion et la dégradation du sol.

SES GRANDES LIGNES

L'entente entre le Canada et les États-Unis sur la qualité de l'eau des Grands Lacs prévoyait de réduire de 2 000 tonnes par an la pollution due au phosphore dans le bassin du lac Erie. PAMPA fait partie de cette entente qui réduira cette pollution de 300 tonnes par an — 200 tonnes provenant des terres agricoles et 100 tonnes provenant de sources industrielles et municipales.

VOLUME II

COLLECTION AND ANALYSIS OF FIELD DATA IN THE PILOT WATERSHEDS STUDY

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Agriculture Canada
for the
Soil and Water Environmental Enhancement Program

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EXECUTIVE SUMMARY

This document provides details of the objectives, methodology, and results of activities related to the collection and analysis of field data pertaining to Pilot Watersheds over a three year period.

The overall objective of the field data collection and analysis effort was to produce field based partial budgets comparing costs and returns (net revenue) between conventional and conservation tillage practices. Achieving this objective involved activity in three areas: developing a data acquisition instrument to facilitate collection of relevant economic data from co-operands; collecting data from co-operands and entering it in a database that would facilitate cleaning, storage, retrieval, and analysis of the data; and carrying out a cost analysis of field operations performed and materials applied.

Pocket sized booklets designed to assist co-operands in recording data on field operations were developed and produced by Conservation Management services (CMS) in 1988. The booklets were based on data requirement specifications and design suggestions provided by Deloitte & Touche. The booklets were first used in the fall of 1988. Field technicians employed by CMS were responsible for distributing the booklets, encouraging co-operands to complete them, collecting completed booklets, doing a preliminary check for completeness and accuracy, and forwarding the booklets to Deloitte & Touche for data entry, cleaning, and analysis.

The database system used to deal with Pilot Watersheds (PWs) data is a slightly modified version of the system developed to deal with Tillage 2000 data. It consists of separate files of information for farms, fields, crops, operations, custom work, materials, and machinery linked together in a "relational" database.

Preparing partial budgets involved costing every operation involved in the production of particular crops, and aggregating those costs to arrive at the cost of all operations involved in the production of a crop. The "Cost Report" program is a complex one which extracts information from the database files,

costs each operation performed, and aggregates costs for each crop grown. The output of the program is a report showing the acreage, yield, machine costs, materials costs, fuel costs, and labour hours involved in the production of individual crops. The financial modelling component takes the output of the cost report, groups the budgets for like crops together, and determines the means and variation of cost components for crops in "test" (conservation tillage) watersheds in comparison to "control" (conventional tillage) watersheds.

This document includes a review of cropping and tillage practices as reported in the Pilot Watersheds Study including cropping patterns, crop yields, level of adoption of conservation tillage practices, reliability of reporting, fuel consumption, labour requirements, and operation coverage, as well as complete crop budgets.

The effort to collect economic information in the Pilot Watersheds produced a large volume of data. While it provides useful information on a number of aspects of the economics of conservation tillage practices, it did not provide a reliable basis for financial modelling at the field level. Perhaps the most important shortcoming of the data is the high degree of variability that it exhibits. Several sources of variability were identified, some of which could have been better controlled through improved collection procedures, but most of which could only be effectively removed by modifying the experimental design. Important sources of variability included: crop management practices, weather, level of adoption, and lack of proper feedback in the data collection activity.

In spite of the problems encountered, the economic data collected in the PWs provided critical input into the field level economic analysis. The method of cost analysis embodied in the costing program provides a prototype for economic analysis of field data at an operation by operation level of detail. This prototype has proven effective in dealing with data from both Tillage 2000 and the Pilot Watersheds Study.

1.0 INTRODUCTION

This report (Volume II: Collection and Analysis of Field Data in the Pilot Watersheds Study) is the first of a series of six technical documents which support and provide more detailed information on key elements of the economic evaluation of conservation tillage technologies (Volume I: Summary Report). It provides details of the objectives, methodology, and results of activities related to the collection and analysis of field data collected in pilot watersheds over a three-year period.

1.1 STUDY BACKGROUND AND OBJECTIVES

The purpose of the PWs sub-program was to implement a variety of appropriate soil conserving technologies on all fields within three test watersheds and compare the soil movement and run-off from these watersheds to three nearby control watersheds (i.e. watersheds where soil conserving technologies were not applied). The focus of this sub-program was to provide a demonstration of how the adoption of soil conserving technologies works in achieving their goal in terms of reduction in soil loss and enhancement of water quality. The PWs sub-program was intended to be a "showcase" for soil conservation field practices.

Previous to the PWs program, the Ontario Ministry of Agriculture and Food (OMAF) was involved in testing and demonstrating alternative tillage practices in a series of side-by-side experiments on selected participating farmers' fields. This program, called Tillage 2000, compared conventional tillage practices to reduced and no-till field operations.

Deloitte & Touche Management Consultants (formerly Deloitte Haskins & Sells) was asked to assess the economic implications of adopting soil conserving technologies based on the results of both the PWs and Tillage 2000 programs. The economic evaluation was to provide an assessment of the economic impact

on participating farmers (at both a field and watershed level) and to assess the downstream macro-economic impact associated with reduced soil loss.

1.2 ORGANIZATION OF REPORT

This report represents Volume II of a seven volume series, consisting of:

Volume I:	An Economic Evaluation of Conservation Tillage Technologies: Summary Report
Volume II:	**Collection and Analysis of Field Data in the PWS**
Volume III:	Field Level Economic Analysis of Alternative Tillage Practices in Southwestern Ontario
Volume IV:	An Economic Evaluation of the Tillage 2000 Program in Ontario
Volume V:	An Economic Evaluation of the Technology Evaluation and Development (TED) Program
Volume VI:	Watershed Level Economic Analysis of Alternative Tillage Practices in Southwestern Ontario
Volume VII:	Macro-Economic Impact Assessment of Soil Conserving Technologies

This document consists of five sections. Section 2.0 reviews the objectives of this component, Section 3.0 describes the methodologies used to collect and analyze field data, Section 4.0 provides selected results pertaining to cropping and tillage practices in the watersheds, and Section 5.0 contains conclusions and recommendations pertaining to this component of the study.

2.0 OBJECTIVES

The overall objective of the field data collection and analysis effort was to produce field based partial budgets comparing costs and returns (net revenue) between conventional and conservation tillage practices. Specific objectives involved in reaching this overall objective included:

- development of a data acquisition instrument which would facilitate the collection from co-operands of data relevant to the economic analysis;

- development of a database system that would provide a vehicle for efficient entry, cleaning, storage, and retrieval of collected data; and

- development of a cost analysis procedure that would allow field operations performed and materials applied to be costed, and costs reported for each crop grown.

The field booklet used for data collection, the relational database system used to organize the data, and the cost analysis procedure used are described in the remainder of this report. The results of the cost analysis carried out are also reported.

The data collection and analysis component was intended to produce crop budgets in sufficient quantity and quality to permit a comparison of both net returns and financial risks associated with conventional as opposed to conservation tillage practices. These budgets were to provide input into the financial analysis component.

3.0 METHODOLOGY

The database system and cost analysis procedure were applied to field data obtained from the Tillage 2000 project in 1988 and 1989. The Tillage 2000 data provided an opportunity to develop and test these components of the data collection and analysis effort before data became available from the Pilot Watersheds. The analysis of Tillage 2000 data was carried right through the financial simulation stage (see Volume IV: An Economic Evaluation of the Tillage 2000 Program in Ontario).

Although many of the database and analysis techniques were first applied to Tillage 2000 data, the emphasis in this report is on data collection and analysis as it pertains to the Pilot Watersheds component of the SWEEP project.

3.1 COLLECTION OF FIELD DATA

Pocket sized booklets designed to assist co-operands in recording data on field operations were developed and produced by Conservation Management Services (CMS) in 1988. The booklets were based on data requirement specifications and design suggestions provided by Deloitte & Touche. The booklets were first used in the fall of 1988 to record fall tillage and other preparation for the 1989 crop season. Field technicians employed by CMS were responsible for distributing the booklets, encouraging co-operands to complete them, collecting completed booklets, doing a preliminary check for completeness and accuracy, and forwarding the booklets to Deloitte & Touche for data entry, cleaning, and analysis.

All field books pertaining to the 1989 crop year were available for analysis by the summer of 1990, but problems with the reporting required that booklets be returned for corrections. Corrected booklets were in hand by March of 1991. Field books for the 1990 and 1991 crop years were available in mid 1991 and early 1992 respectively.

Entry of data from the watersheds began immediately upon receipt of booklets pertaining to the 1989 crop year. Booklets were returned to the field after an initial data entry effort to obtain missing data and correct errors and inconsistencies. "Clean" data for 1989 was available in mid 1991. The nine month period from August 1991 to April 1992 involved an intensive effort to enter and clean data from the 1990 and 1991 crop years, modify the analysis procedures that had been used for Tillage 2000 data, and complete the preparation of crop budgets.

A final review of data submitted by co-operands was carried out in mid 1992 by preparing a printout of all data in the database with all operations arranged chronologically for each field and crop. These printouts were reviewed by a Deloitte & Touche agronomist and the watershed technicians for accuracy and consistency.

The first crop budget results for the Kettle watershed were available in early 1992, and the analysis of the other two watersheds was completed in mid 1992.

3.2 ANALYSIS OF FIELD DATA

This section deals with the structure of the database system used to organize and provide access to data from the field diaries, and the analysis procedures applied to the data.

3.2.1 Database Structure

The database system used in the PWs component is a slightly modified version of the system used to deal with T2000 data. In addition the programming for database manipulation and analysis is in the Pascal language rather than dBase III. Using Pascal, a compiled language with more flexibility, reduced data

processing time to a fraction of that required using a dBase III program.

To minimize the repetition of data, the database is divided into a number of files. The records in each file are related to each other using "key" fields. In general, the files contain data from a specific section in the field diary. The files and the relationships between them are described below.

The **FARM** file contains general information on the farm including the co-operands full name and is linked to all other files with a four digit farm code.

The **FIELD** file contains information pertinent to individual fields including the acreage and their location in the "test" or "control" watersheds. All files requiring a link to the field file are linked using the farm code plus a three digit field code.

The **CROP** file contains information on crops grown in each field. Items include the crop grown, the yield obtained, codes reflecting assessments of the reliability of data recorded in field diaries, and the crop immediately preceding this one (to facilitate identification of rotations). Records in this file are linked to other files as necessary using the farm and field codes and a two digit crop code.

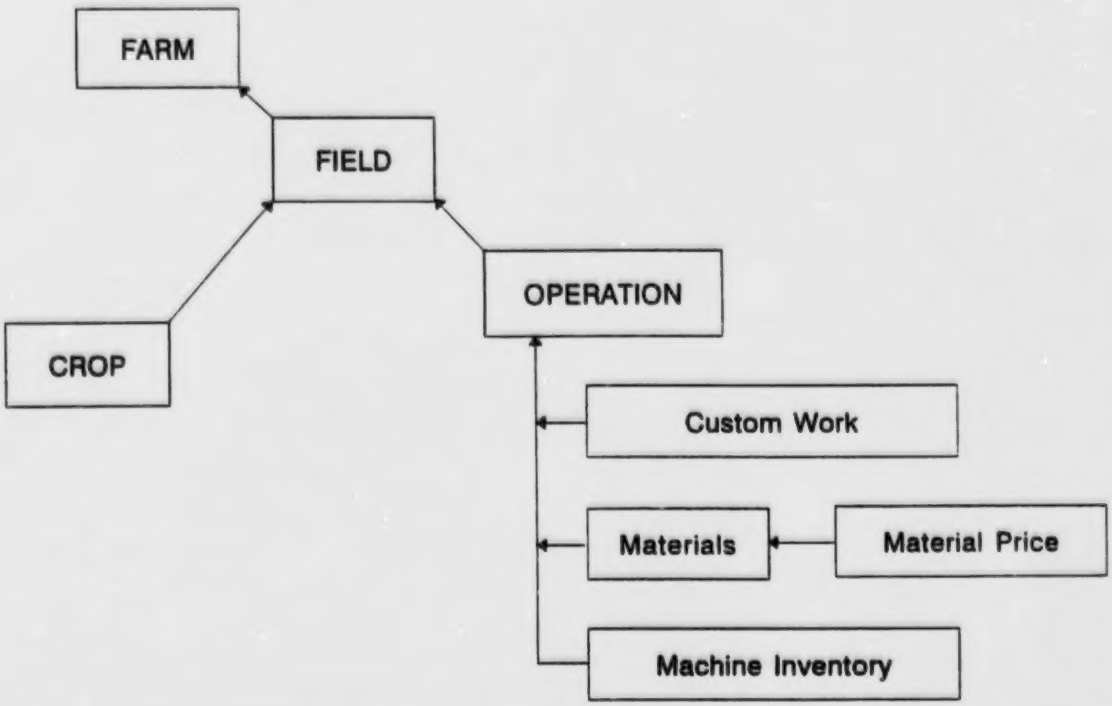
The **OPERATIONS** file is the core of the system. It contains a variety of information on the operation taken directly from the field diary: date, operation performed, percent of field covered, total time in field, fuel used, and equipment used. It is linked to other files on farm and field codes, a six digit date code, and a one digit sequence code (to uniquely identify multiple operations in the same field on the same day).

The following three files merely elaborate on aspects of the operations file. The **CUSTOM** work file includes the cost of custom work and who performed it. The **MATERIALS** file contains information on the type, brand, analysis, and rate of application of any materials applied. The **MACHINE INVENTORY** file contains

additional information on the equipment used to perform the operation including type, brand, horse power or other descriptive information, and parameters required to calculate operating costs.

Finally, the **MATERIAL PRICE** file contains a list of materials and their prices which the materials file can access to price materials used. The linkages between files are shown in FIGURE 3.1.

FIGURE 3.1 Linkages Between Database Files



3.2.2 Farm Report

A great deal of data cleaning was carried out manually as a part of the data entry exercise. Systematic examination of the data for errors and omissions was largely carried out as a part of the "Farm Report" program which produces a listing of all data pertaining to operations, organized chronologically, for each farm and field. The program reports errors such as:

- machines without operations
- materials without operations
- operations without fields
- machines not in inventory
- materials not priced
- numeric fields containing invalid numbers (non-numeric characters)

The farm reports were useful for a number of purposes. They provided a convenient way to examine the sequence of operations involved in the production of individual crops on specific fields. The reports were used as the basis for:

- review by a Deloitte & Touche agronomist to identify inconsistencies;

- review by watershed technicians to provide missing data wherever possible and correct inconsistencies;

- formulation of representative cropping scenarios consistent with actual field practices in each of the watersheds.

3.2.3 Cost Report

One of the primary objectives of the whole data gathering exercise was to be

able to cost each operation involved in the production of a particular crop, and to be able to aggregate those costs for all the operations involved in production of a crop. The "Cost Report" program is a complex one which extracts information from the database files, costs each operation performed, and aggregates operation costs for each crop grown. The output of the program is a report showing the acreage, yield, machine costs, materials costs, fuel costs, and labour hours involved in the production of individual crops. Machine costs were broken down into four categories: operations that took place before the planting operation, the planting operation, operations that took place after planting but before harvest, and harvest operations.

Most of the cost calculations are straightforward. The biggest difficulty to be overcome in pricing materials was dealing with the variety of units used in application rates. Although the units used in this report are hectares, land areas were virtually always reported in the field diaries as acres. Units used to report application rates varied widely both between kinds of materials and within kinds of materials, and often included a mixture of imperial and metric units (e.g. litres/acre).

Details of the materials costing procedure can be found in the MATCOST function (see Cost Report program listing in APPENDIX I).

The most complex calculations involved determining the cost of operating machinery. The calculations performed can be summarized as follows:

Definitions:

market price = typical dealer selling price for used equipment
salvage value = 25% of market value
service life = 10 years for power equipment, 15 years for other equipment
R&M factor = a repair and maintenance factor (see TABLE 3.1)
annual hours = typical annual hours of use (see TABLE 3.1)

Annual Costs:

depreciation = (market price - salvage value) / service life

finance cost = 10 % of (market price + salvage value) / 2

insurance cost = 1.5% of market price

Hourly Costs:

R&M cost = (market price / 1000) * R&M factor

Total Cost per Hour of Operation:

total hourly cost = (annual cost / annual hours) + R&M cost

TABLE 3.1 Parameters Used in Costing Farm Machinery Operation

Machine	Annual Hours	R & M Factor
Tractor	400	0.09
Tillage Equipment	100	0.48
Seeding and Planting Equipment	100	0.50
Fertilizer Applicators	60	1.00
Sprayers	50	0.83
Mowers/Conditioners	60	0.60
Forage Harvesters, Wagons and Blowers; Swathers; Haybines; Corn Pickers/Shellers	80	0.40
Rakes, Bale Stookers	60	0.40
Balers	80	0.32
Combines	200	0.30
Manure Spreaders, Hydraulic Loaders, Stone Pickers	100	0.24
Wagons and Boxes	200	0.20
Other (10 year life)	100	0.45
Other (15 year life)	100	0.65

Fuel and lubrication costs are not included in machine costs but are reported as a separate cost item. The fuel component is simply the amount of fuel used at a fixed price. Lubrication costs are accounted for by increasing the calculated cost of fuel by 15%.

Because time in the field and fuel use were not reported or poorly reported for a large proportion of operations it was necessary to provide default values for these parameters. The system of providing default values was included in the cost report to avoid making extensive changes in the database. This was consistent with the principal that data in the database should reflect as closely as possible the data recorded in the field booklets.

Providing default values was a two step process. First, default values were determined by finding the mean of values that had been provided by co-operands in the Kettle watershed. These means for hours in the field, diesel consumption, and gasoline consumption for each of the operation times are shown in TABLE 3.2. The second step was to include a routine in the costing program to examine values reported for these parameters and replace them with the default value if no value was reported, or if the reported value fell outside of a range from 0.5 the default value to 1.5 times the default value. See the FUELCOST function and CHECKTIME procedure in the COST REPORT program listing in APPENDIX I for details of how default values were provided.

TABLE 3.2 Default Values for Time in the Field and Fuel Use

	Fuel Use (litres/acre)		Time Required
Operation	Diesel	Gasoline	(acres/hour)
MOLDBOARD PLOW	10.3	10.0	2.3
CHISEL PLOW	9.0	9.0	5.3
DISC	5.2	5.0	4.7
CULTIVATE	4.1	4.0	8.5

Operation	Fuel Use (litres/acre)		Time Required
	Diesel	Gasoline	(acres/hour)
PACK	4.5	4.5	6.2
ROW CULTIVATE	2.5	2.5	5.7
FERTILIZE	3.3	3.0	8.5
SPRAY	1.8	1.7	10.8
PLANT	3.2	3.5	4.7
COMBINE	10.6	10.0	4.0
CUT	5.5	5.5	2.7
RAKE	5.0	5.0	2.5
BALE	4.8	5.0	2.0
CHOP	5.0	5.0	2.5
HAUL	5.0	5.0	2.5
ROTARY HOE	5.0	5.0	2.5
PICK	5.0	5.0	2.5
STONE	5.0	5.0	2.5
OTHER	9.0	9.0	5.0

2.3 FINANCIAL MODELLING

The financial modelling component begins by taking the output of the cost report, grouping the records for like crops grown in "test" and "control" watersheds together, and determining the mean and variation of costs in the various categories. This was done for seven crop/rotation combinations in the Kettle watershed as follows:

- corn following corn
- corn following soybeans
- corn following wheat
- soybeans following corn

- soybeans following soybeans
- soybeans following wheat
- wheat following soybeans

A similar analysis was carried out using a subset of the most reliable data from each watershed. This included corn following corn in the Kettle and Pittock watersheds, and soybeans following soybeans in the Essex watershed.

Because of a number of experimental design and data related problems discussed later in this report, the watershed data was of limited use in the financial analysis. The financial analysis component is discussed in detail in Volume III: Field Level Economic Analysis.

4.0 RESULTS

4.1 FIELD BOOKS

The focus of most data collection, entry, management, and analysis activity was the field booklet. It was designed to capture the details of every operation carried out by co-operating farmers on their fields in PWS watersheds. The intent was to have co-operands complete one page of the field booklet for each field operation. All the pertinent information about the operation could be provided on the page: date, field on which the operation was performed, labour input, materials and machinery used, and fuel used by power machinery.

In many cases co-operators understood what was required and completed field books correctly. An example of a correctly completed entry in a field book is presented in FIGURE 4.1.

In other cases, however, the field book entries omitted essential information, or presented information in such a way that it was difficult or impossible to obtain accurate data on individual operations. An example of information that was very difficult to interpret is given in FIGURE 4.2 which illustrates a number of problems:

1) this page attempts to provide information on six operations, not one;

2) the linkages between tractors and implements are in a different colour ink indicating that they were added after the original entry by the co-operand (?), the watershed technician (?), or the person entering data (?);

3) although an estimate of fuel use is given, it is impossible to determine how much fuel was used in which operation;

4) there is no indication of what kind of manure was spread;

FIGURE 4.1 Example of a Correctly Completed Field Diary Entry

FIELD OPERATIONS REPORT Date may 26

Field No. 5 Percent Of Field Covered 100 %

Person(s) Doing Field Work: Self [x] [redacted]

Others [ ] Give Name(s) ____

Cost If Custom Work: $ ____ /hr or $ ____ /ac

Total Time In Field: 6 hr(s)

SEED

Crop Type	Variety	Seed Type*	Rate/Ac
corn	Pioneer 3902	2	28000

* Seed Type Code: 1=foundation, 2=certified, 3=Can#1, 4=bin run or own seed, 5=other.

FERTILIZER

Type	Analysis	Rate
alpine	6-24-6	20L/ac.

INSECTICIDE / HERBICIDE / FUNGICIDE / ETC.

Type	Product Name	Formulation	Rate
159	Cyan		66 lb/ac

FUEL USED IN FIELD

Type: Diesel [x] Or Gas [ ]

Amount: 25 Litres [x] or Gallons [ ]

Was Amount Measured [ ] or Estimated? [x]

OTHER MATERIALS - Description and amount used

____

____

OPERATION PERFORMED	EQUIPMENT USED 7
[ ] Moldboard	[ ] IH 1086- 130 HP
[ ] Chisel	[ ] IH 834- 70 HP
[ ] Disc	[x] IH 434- 40 HP
[ ] Cultivate	[ ] PLOW-LH. 720
[ ] Pack/Harrow	[ ] DISC-LH. 475
[ ] Row/Cultivate	[ ] S TINE CULT.-MCKEE
[ ] Fertilizer	[ ] CHISEL PLOW-MOHAWK
[ ] Spray	[x] PLANTER-LH. 56
[x] Plant	[ ] SEED DRILL-LH.
[ ] Combine	[ ] MANURE SPREADER-N.I.
[ ] Cut	[ ] SPRAYER-G. WHITE
[ ] Rake	[ ] LIQ. MANURE-HUSKY
[ ] Bale	[ ] COMBINE-LH. 715
[ ] Chop/Blow	[ ] RAKE-NEW IDEA
[ ] Haul	[ ] BALER-MF 3
[ ]	[ ]
[ ]	[ ]
[ ]	[ ]

Comments/Other Activities, Etc.

____

____

____

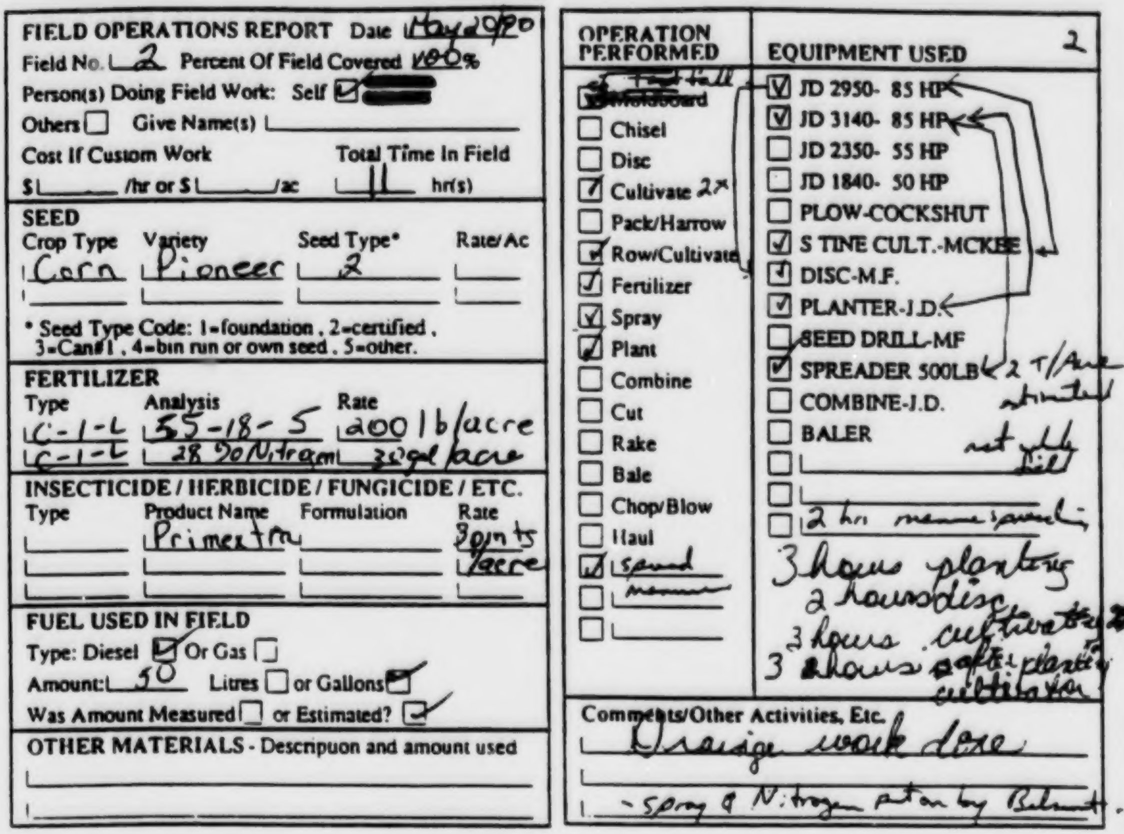
5) there is no indication of the cost of custom application of Primextra and liquid nitrogen;

6) it is unclear whether the mixed fertilizer (55-18-5) was applied during the seeding operation. There is no apparent machine complement to indicate that it was spread in a separate operation;

7) while a row cultivate operation is indicated, there is nothing in the machinery complement to indicate what tractor or implement was used, and it can be safely assumed that a row cultivation would not be performed on May 20, the day seeding apparently took place;

8) a seeding rate is not given.

FIGURE 4.2 Example of an Incorrectly Completed Field Diary Entry



FIELD OPERATIONS REPORT Date May 20/90
Field No. 2 Percent Of Field Covered 100%
Person(s) Doing Field Work: Self ☑ [redacted]
Others ☐ Give Name(s)
Cost If Custom Work: $ /hr or $ /ac — Total Time In Field: 11 hr(s)

SEED
Crop Type: Corn — Variety: Pioneer — Seed Type*: 2 — Rate/Ac:
* Seed Type Code: 1=foundation, 2=certified, 3=Can#1, 4=bin run or own seed, 5=other.

FERTILIZER
Type / Analysis / Rate
C-I-L — 55-18-5 — 200 lb/acre
C-I-L — 28% Nitrogen — 30 gal/acre

INSECTICIDE / HERBICIDE / FUNGICIDE / ETC.
Type / Product Name / Formulation / Rate
— Primextra — — 3 pints/acre

FUEL USED IN FIELD
Type: Diesel ☑ Or Gas ☐
Amount: 50 Litres ☐ or Gallons ☑
Was Amount Measured ☐ or Estimated? ☑

OTHER MATERIALS - Description and amount used

OPERATION PERFORMED
☑ ~~Moldboard~~ fall
☐ Chisel
☐ Disc
☑ Cultivate 2X
☐ Pack/Harrow
☑ Row/Cultivate
☑ Fertilizer
☑ Spray
☑ Plant
☐ Combine
☐ Cut
☐ Rake
☐ Bale
☐ Chop/Blow
☐ Haul
☑ spread
☐ manure
☐

EQUIPMENT USED 2
☑ JD 2950- 85 HP
☑ JD 3140- 85 HP
☐ JD 2350- 55 HP
☐ JD 1840- 50 HP
☐ PLOW-COCKSHUT
☑ S TINE CULT.-MCKEE
☑ DISC-M.F.
☑ PLANTER-J.D.
☐ SEED DRILL-MF
☑ SPREADER 500LB — 2 T/Acre estimated
☐ COMBINE-J.D.
☐ BALER — not yet ... bill
☐
☐
☐ 2 hrs manure spreading

3 hours planting
2 hours disc
3 hours cultivating
3 hours after planting cultivation

Comments/Other Activities, Etc.
Drainage work done
- Spray & Nitrogen put on by Belmont.

Another common difficulty was operations which involved more than one field. Manually allocating time in the field, and fuel use, between fields based on the acreage was a time consuming and error prone operation.

The information on the machinery owned by co-operands contained very little information on purchase price and age of individual machines. As a result the only workable approach to machine costs was to obtain market values of machines from "guide" publications which summarize prices at which dealers buy and/or sell used equipment. This process is also time consuming and also somewhat subjective because of difficulty finding all of the equipment in the guides.

Co-operands were not asked to supply the price paid for materials and fuel. Knowing the variation between farms in terms of prices paid for materials would add nothing to the analysis so it was decided early in developing the data collection methodology to rely on input suppliers for a common set of materials prices. A list of materials was first developed by obtaining a list of all the materials used in the watershed and removing duplications. Prices were then obtained from input suppliers based on price lists applicable in the 1990/91 growing season.

One difficulty that had to be overcome was the pricing of blended fertilizers. It was impractical to ask a fertilizer dealer to price a wide range of blends so prices of basic fertilizer ingredients (urea, phosphate, potash, and MAP) were obtained and used in a simple "least cost" algorithm to estimate prices of blends.

In many respects data entry and cleaning proceeded much as anticipated. One unforseen problem that had to be overcome was the difficulty caused by the need to analyze data in chronological order in each field (the order in the database) while it was typically recorded in chronological order across all fields (the order in the field books). This made it very difficult to cross check records in the database with entries in the field books. To deal with this problem a

system of "locators" was added to the field books (e.g. co-operand 3, booklet 4, page 6) and the locator for each operation was included in the database information pertaining to each operation.

There were many instances of missing or obviously incorrect data, especially with regard to time in the field, fuel consumption, and machinery used. Correcting most of these by reference back to the co-operand was not practical given the nature of the information and the relevant time frame. Asking co-operands to recall time and fuel consumption for a particular operation in a particular field from one to three years ago is not very likely to produce reliable information. Instead default values for time and fuel consumption were developed for various operations.

In other cases such as material application rates, machinery used in operations, and crop yields, missing data could be supplied by reference to other similar applications or operations, or on the experience of the field technician in dealing with the co-operand.

The data entry and cleaning process was extremely frustrating at times. In a large number of cases the person entering the data had to exercise judgements that injected an element of subjectivity into the data. This was impossible to avoid because the data entry process was so isolated from the data recording process. Those entering data had access to the co-operands only through the field technicians. Slow turnaround of completed booklets made it impossible to identify problems and get back to the co-operand for corrections in a reasonable length of time. In addition, there was no opportunity to print detailed reports and return them to the co-operands for verification. If this is done promptly it is one of the most effective ways of ensuring complete and accurate data collection.

As analysis of the data supplied by the PWs co-operands progressed it became increasingly apparent that it would not provide an adequate basis for the analysis in the financial modelling and watershed optimization components of

the economic evaluation. A number of factors contributing to this situation were identified as the analysis progressed:

- flaws in the data collection and verification process;
- unreliable data recording on the part of co-operands;
- failure to clearly identify the level of soil conservation technology pertaining to each field and crop;
- extreme variability among co-operands both within and between test and control watersheds in almost every aspect of their farming operations.

The first point has already been dealt with in the discussion above. The second and third points were brought to light by a review of the field diaries carried out for CMS by Don Lobb and the field technicians in which they reviewed each of the field diaries and made a subjective assessment of: (a) the reliability of the data, and (b) the degree to which soil conservation technologies had been adopted. A summary of their assessment reveals that a large proportion of the field data was considered unreliable and that adoption of soil conservation technologies was low, even in "test" watersheds. Only a small percentage of participating growers actually recorded their operations with a high degree of accuracy and consistency. This has serious implications for the economic analysis component of the whole watershed experiment because it implies that the differences between "test" and "control" may be too small to produce significant differences in the economic parameters being measured.

4.2 CROPPING AND TILLAGE PRACTICES

4.2.1 Reporting of Field Operations

Kettle

Cropping activity reported in field booklets covered approximately 650 hectares in the Kettle Pilot Watershed. Of this approximately 345 hectares were in the control watershed and 305 hectares were in the test watershed. Approximately 12 hectares could not be assigned to either the test or control watershed for the purposes of economic analysis because the watershed boundary passed through a field on which uniform cropping practices were carried out. The area for which activity was reported in the 1989 crop year was lower than the subsequent two years, which probably reflects inertia in getting all the co-operands to participate fully in the first year.

TABLE 4.1 Area For Which Field Data Was Reported, Kettle Watershed

Year	Control		Test		Unallocated	
	Fields	Acres	Fields	Acres	Fields	Acres
1989	30	754.00	46	738.20	3	23.00
1990	32	844.00	46	753.20	4	28.00
1991	33	847.00	51	743.20	5	28.00

Pittock

Cropping activity reported in field booklets covered approximately 540 hectares in the Pittock Pilot Watershed. Of this approximately 260 hectares were in the control watershed and 280 hectares were in the test watershed. The area for which activity was reported was relatively stable during the three year study period.

TABLE 4.2 Area For Which Field Data Was Reported, Pittock Watershed

Year	Control		Test		Unallocated	
	Fields	Acres	Fields	Acres	Fields	Acres
1989	33	610.00	48	677.00	-	-
1990	34	648.00	59	727.00	-	-
1991	38	630.00	58	698.00	-	-

Essex

Cropping activity reported in field booklets covered approximately 525 hectares in the Essex Pilot Watershed. Of this approximately 190 hectares were in the control watershed and 335 hectares were in the test watershed. The area for which activity was reported in the control watershed in 1991 was substantially lower than the previous two years.

TABLE 4.3 Area For Which Field Data Was Reported, Essex Watershed

Year	Control		Test		Unallocated	
	Fields	Acres	Fields	Acres	Fields	Acres
1989	21	542.00	37	838.00		
1990	20	495.00	38	816.00		
1991	14	357.00	38	843.00	5	28.00

4.2.2 Cropping Patterns

Kettle

Corn, soybeans, and wheat were the main crops in the Kettle watershed (36%,

25%, and 14% of crop acreage respectively) over the three year period. Processing crops (sweet corn and peas) were important relative to the other watersheds and accounted for 10% of crop acreage. Small grains (barley and oats), pasture, and hay made up the remaining 15% of crop acreage. A detailed breakdown of crop acreages by year is presented in TABLE 4.4.

TABLE 4.4 Cropping Patterns in the Kettle Watershed

		Grain Corn	Silage Corn	Soybeans	Wheat	Pasture, Hay & Small Grains	Other	Total
1989	acres	403	16	441	269	255	131	1,515
	fields	23	1	25	11	14	5	79
1990	acres	616	5	436	224	222	122	1,625
	fields	25	1	23	14	15	4	82
1991	acres	671.0	22.5	318	173.5	223	210	1,618
	fields	32	3	23	11	14	6	89

Pittock

Corn was the main crop in the Pittock watershed with 52% of crop acreage over the three year period. In contrast to the other two watersheds, only small areas of soybeans and wheat were grown in this watershed. However, dry bean crops (white, kidney, and cranberry) were important (relative to the other watersheds) and accounted for about 15% of crop area. Small grains (barley and oats), pasture, and hay made up the remaining 20% of crop acreage. A detailed breakdown of crop acreages by year is presented in TABLE 4.5.

TABLE 4.5 Cropping Patterns in the Pittock Watershed

		Grain Corn	Silage Corn	Soybeans	Wheat	Pasture, Hay & Small Grains	Other	Total
1989	acres	585	9	85	56	340	212	1,287
	fields	35	1	4	5	25	11	81
1990	acres	596	48	45	170	263	253	1,375
	fields	38	3	3	10	19	20	93
1991	acres	797	25	83	64	213	146	1,328
	fields	48	4	6	6	20	12	96

Essex

Soybeans, corn, and wheat were the main crops in the Essex watershed (56%, 14%, and 10% of crop acreage respectively) over the three year period. Sweet corn, nato beans, sunflower, and dry peas accounted for 16% of crop acreage. Small grains (barley and oats), pasture, and hay made up only 4% of crop acreage. A detailed breakdown of crop acreages by year is presented in TABLE 4.6.

TABLE 4.6 Cropping Patterns in the Essex Watershed

		Grain Corn	Sweet Corn	Soybeans	Wheat	Pasture, Hay & Small Grains	Other	Total
1989	acres	249	50	682	138	88	173	1,380
	fields	7	1	29	8	7	6	58
1990	acres	167	55	706	184	42	157	1,311
	fields	5	2	33	9	4	5	58
1991	acres	128	24	799	49	18	182	1,200
	fields	9	1	31	2	2	7	52

4.2.3 Crop Yields

The average yields shown in TABLE 4.7 (Kettle), TABLE 4.8 (Pittock) and TABLE 4.9 (Essex) are presented for information purposes only. **No useful and statistically valid inferences about the relationship between yields in test and control watersheds can be drawn from the yield data collected.** Yields are simple averages of yields reported in each field; they represent a mixture of reporting based on farmers' estimates, weigh wagon weights, and elevator weights; and there are a large number of factors, other than tillage practices, influencing differences in yield (including differences in seed, fertilizer, and planting date to mention only a few).

TABLE 4.7 Simple Averages of Yields Reported in the Kettle Watershed

		Control			Test		
Year		Grain Corn	Soybeans	Wheat	Grain Corn	Soybeans	Wheat
1989	bu/acre	127.1	34.4	63.68	116.8	38.1	51.37
	fields	7	6	5	11	17	6
1990	bu/acre	106.3	39.3	65.9	122.0	32.8	69.5
	fields	12	5	6	11	16	8
1991	bu/acre	100.1	33.3	-	99.8	29.1	54.6
	fields	14	7	-	15	15	9

TABLE 4.8 Simple Averages of Yields Reported in the Pittock Watershed

		Control			Test		
Year		Grain Corn	Soybeans	Wheat	Grain Corn	Soybeans	Wheat
1989	bu/acre	131.1	58.8	92.0	127.1	39.3	71.5
	fields	17	1	1	14	3	4
1990	bu/acre	126.5	-	73.5	123.3	42.5	72.9
	fields	11	-	4	16	3	5
1991	bu/acre	152.8	51.0	75.0	157.5	43.6	81.0
	fields	19	2	4	20	4	1

TABLE 4.9 Simple Averages of Yields Reported in the Essex Watershed

Year		Control			Test		
		Grain Corn	Soybeans	Wheat	Grain Corn	Soybeans	Wheat
1989	bu/acre	133.0	43.17	58.7	123.3	38.51	70.8
	fields	2	11	3	5	18	5
1990	bu/acre	111.6	39.7	88.6	147.5	44.9	78.0
	fields	3	9	2	2	22	6
1991	bu/acre	60.0	24.2	45.0	57.0	26.4	37.0
	fields	2	6	1	7	23	1

4.2.4 Level of Adoption and Reliability of Field Operations Data

Kettle

TABLE 4.10 shows the results of the assessment of data reliability in the Kettle test and control watersheds, and the level of adoption of conservation tillage practices in the test watershed. In the 1989 crop year approximately 35% of fields in the test watershed were considered to have adopted conservation tillage practices and to have provided moderately to highly reliable data. In the 1990 crop year this increased to 52%, and in 1991 to 56%. In the control watershed, between 60 and 80 percent of the area in the watershed was considered to have moderately reliable data. Only a very small area was considered to have highly reliable data.

Pittock

TABLE 4.11 shows the results of the assessment of data reliability in the Pittock test and control watersheds, and the level of adoption of conservation tillage practices in the test watershed. In the 1989 crop year approximately 20% of area in the test watershed was considered to have adopted conservation tillage practices and to have provided moderately to highly reliable

data. In the 1990 crop year this decreased to 15%, but increased to 39% in 1991. In the control watershed, between 60 and 70 percent of the area in the watershed was considered to have moderately to highly reliable data.

Essex

TABLE 4.12 shows the results of the assessment of data reliability in the Essex test and control watersheds, and the level of adoption of conservation tillage practices in the test watershed. In the 1989 crop year approximately 21% of fields in the test watershed were considered to have adopted conservation tillage practices and to have provided moderately to highly reliable data. In the 1990 crop year it remained about the same at 20%, but increased to 46% in 1991. In the control watershed, between 85 and 95 percent of the area in the watershed was considered to have moderately to highly reliable data.

Table 4.10: Level of Adoption and Reliability of Data, Kettle Watershed

	Control			Test - No Adoption			Test - Honest Effort			Test - Adoption in Place			Total Test		
	1989	1990	1991	1989	1990	1991	1989	1990	1991	1989	1990	1991	1989	1990	1991
Low Confidence	250	219	158	11	27	66.5	6	25	-	13	22	26	30	74	92.5
Medium Confidence	487	357	621	276	252	101	145	7	62	153	327	282.5	574	586	445.5
High Confidence	-	90	-	-	-	40	-	-	-	90	28	87	90	28	127
Total	737	666	779	287	79	207.5	151	32	62	256	377	395.5	694	688	665

Table 4.11: Level of Adoption and Reliability of Data, Pittock Watershed

	Control			Test - No Adoption			Test - Honest Effort			Test - Adoption in Place			Total Test		
	1989	1990	1991	1989	1990	1991	1989	1990	1991	1989	1990	1991	1989	1990	1991
Low Confidence	239	177	218	142	60	33	19	22	16	23	78	-	184	160	49
Medium Confidence	136	211	130	231	234	278	35	112	60	87	67	64	353	413	402
High Confidence	235	260	282	50	65	37	40	46	-	50	43	210	140	154	247
Total	610	648	630	423	359	348	94	180	76	160	188	274	677	727	698

Table 4.12 Level of Adoption and Reliability of Data, Essex Watershed

	Control			Test - No Adoption			Test - Honest Effort			Test - Adoption in Place			Total Test		
	1989	1990	1991	1989	1990	1991	1989	1990	1991	1989	1990	1991	1989	1990	1991
Low Confidence	77	68	9	236	211	277	-	43	5	-	-	16	236	254	298
Medium Confidence	410	372	303	65	25	38	28	6	-	-	36	160	93	67	198
High Confidence	55	55	45	34	164	38	299	200	95	176	131	214	509	495	347
Total	542	495	357	335	400	353	327	249	100	176	167	390	838	816	843

4.2.5 Labour Requirements and Fuel Usage

Fuel use was perhaps the least reliable of all data recorded in the field books. Cases where fuel use was measured were the exception rather than the rule. There was a high degree of variation in the data as shown by the range (minimum and maximum), and by the standard deviations presented in TABLES 4.14, 4.17, and 4.20. The coefficient of variation (the ratio of standard deviation to mean expressed as a percentage) is very high, often exceeding 100%. While part of this variation is due to differences in the width of implements used and the horsepower of tractors, a large part is also due to anomalies and inconsistencies in the data recorded in the field booklets.

In the Cost Report program default labour and fuel data were used to replace field data that was missing or outside of a reasonable range. A discussion of the methods used to provide defaults can be found in section 3.2.3.

Kettle

Fuel use and hours in the field were available to calculate fuel use per hour in only 57% of operations in the Kettle watershed. Fuel use per acre could be calculated for about 60% of operations, and acres per hour could be calculated for 78% of operations. The minimum, maximum, mean, and standard deviation for these variables is presented in TABLES 4.13 to 4.15.

TABLE 4.13 Time Required for Field Operations (Acres/Hour), Kettle Watershed

Operation	Number of Observations	Mean	S.D.
BALE	13	2.02	1.58
CHISEL PLOW	30	4.89	3.02
COMBINE	184	4.78	10.91
CULTIVATE	326	8.73	7.36
CUT	13	3.03	2.15
DISC	49	5.16	3.02
FERTILIZE	144	11.17	18.61
MOLDBOARD PLOW	115	2.53	2.35
PACK	23	6.70	6.26
PLANT	214	4.77	6.22
ROTARY HOE	10	11.50	4.66
ROW CULTIVATE	44	4.95	4.02
SPRAY	199	12.49	15.44

TABLE 4.14 Fuel Consumption in Field Operations (Litres/Hour), Kettle Watershed

Operation	Number of Observations	Mean	S.D.
BALE	13	5.69	2.63
CHISEL PLOW	17	22.28	11.87
COMBINE	152	22.89	29.49
CULTIVATE	206	19.24	12.54
CUT	13	11.42	7.98
DISC	33	16.17	12.97
FERTILIZE	99	12.29	10.46
MOLDBOARD PLOW	82	15.90	10.17
PACK	19	12.23	14.31
PLANT	155	8.95	8.74
ROW CULTIVATE	38	8.31	6.02
SPRAY	164	12.70	12.60

TABLE 4.15 Fuel Consumption in Field Operations (Litres/Acre), Kettle Watershed.

Operation	Number of Observations	Mean	S.D.
BALE	17	5.05	5.35
CHISEL PLOW	17	6.48	4.02
COMBINE	153	9.46	13.25
CULTIVATE	212	3.31	2.35
CUT	13	4.48	2.29
DISC	36	4.04	4.71
FERTILIZE	107	2.87	3.72
MOLDBOARD PLOW	84	9.16	7.52
PACK	19	4.16	6.65
PLANT	163	3.08	3.12
ROW CULTIVATE	40	2.75	2.43
SPRAY	174	1.73	1.95

Pittock

Fuel use and hours in the field were available to calculate fuel use per hour in only 54% of operations in the Pittock watershed. Fuel use per acre could be calculated for only 52% of operations, and hours per acre could be calculated for 83% of operations. The minimum, maximum, mean, and standard deviation for these variables is presented in TABLES 4.16 to 4.18.

TABLE 4.16 Time Required for Field Operations (Acres/Hour), Pittock Watershed

Operation	Number of Observations	Mean	S.D.
BALE	108	2.49	1.43
CHISEL PLOW	14	4.44	2.21
CHOP	29	3.03	1.90
COMBINE	208	2.38	1.82
CULTIVATE	303	7.84	7.40
CUT	90	3.34	2.49
DISC	81	4.96	2.70
FERTILIZE	112	12.78	16.01
HARROW	26	5.39	2.94
HAUL	102	3.21	4.83
MOLDBOARD PLOW	181	2.87	2.12
MULCH	12	6.83	3.59
PACK	59	6.41	3.90
PLANT	224	4.36	2.72
PULL	34	4.22	4.36
RAKE	64	3.85	2.03
ROTARY HOE	11	6.01	4.88
ROW CULTIVATE	45	4.64	3.26
SHRED	13	6.02	0.68
SPRAY	221	11.37	7.32
STONE	19	5.28	4.51
WIND ROW	26	4.15	0.90

TABLE 4.17 Fuel Consumption in Field Operations (Litres/Hour), Pittock Watershed

Operation	Number of Observations	Mean	S.D.
BALE	98	9.49	4.80
CHISEL PLOW	11	31.43	35.37
CHOP	27	19.25	15.73
COMBINE	133	22.95	19.81
CULTIVATE	176	32.25	64.06
CUT	80	9.59	4.04
DISC	58	23.32	32.77
FERTILIZE	67	23.65	32.77
HARROW	20	10.26	2.18
HAUL	65	14.23	8.72
MOLDBOARD PLOW	125	26.30	27.80
MULCH	11	10.15	6.18
PACK	49	33.40	102.18
PLANT	146	14.20	20.27
PULL	11	10.40	6.93
RAKE	52	6.21	3.00
ROW CULTIVATE	25	11.63	8.13
SHRED	13	14.88	8.31
SPRAY	107	13.50	20.31
WIND ROW	10	8.61	0.78

TABLE 4.18 Fuel Consumption in Field Operations (Litres/Acre), Pittock Watershed

Operation	Number of Observations	Mean	S.D.
BALE	94	5.62	4.83
CHISEL PLOW	11	25.57	66.89
CHOP	26	8.09	5.91
COMBINE	122	17.30	28.14
CULTIVATE	175	8.04	17.58
CUT	77	4.60	4.41
DISC	58	8.12	17.37
FERTILIZE	65	6.53	12.24
HARROW	20	2.10	0.62
HAUL	61	8.79	8.17
MOLDBOARD PLOW	126	18.99	28.93
MULCH	12	7.08	15.07
PACK	49	6.18	14.17
PLANT	135	8.75	24.02
RAKE	49	2.24	1.60
ROW CULTIVATE	27	7.43	18.02
SHRED	13	2.58	1.61
SPRAY	101	3.41	10.91
WIND ROW	10	3.52	1.18

Essex

Fuel use and hours in the field were available to calculate fuel use per hour in only 39% of operations in the Essex watershed. Fuel use per acre and acres per hour could be calculated for only 44% of operations. The minimum, maximum, mean, and standard deviation for these variables is presented in TABLES 4.19 to 4.21.

TABLE 4.19 Time Required for Field Operations (Acres/Hour), Essex Watershed

Operation	Number of Observations	Mean	S.D.
BALE	23	3.12	1.39
CHISEL PLOW	13	2.32	2.11
COMBINE	57	3.06	3.25
CULTIVATE	88	6.76	4.04
CUT	21	3.24	0.72
DISC	51	4.53	4.42
FERTILIZE	41	18.10	39.91
FURROW	25	31.76	15.06
HOE	16	1.76	0.91
MOLDBOARD PLOW	44	2.07	1.83
PLANT	84	5.27	6.70
RAKE	23	6.99	3.56
SPRAY	84	7.61	7.87

TABLE 4.20 Fuel Consumption in Field Operations (Litres/Hour), Essex Watershed

Operation	Number of Observations	Mean	S.D.
BALE	19	10.07	2.25
COMBINE	55	20.14	6.73
CULTIVATE	84	26.68	20.88
CUT	18	9.27	1.64
DISC	50	29.49	21.39
FERTILIZE	33	11.39	6.33
FURROW	21	12.56	4.11
MOLDBOARD PLOW	41	20.26	15.50
PLANT	80	13.85	10.35
RAKE	20	8.95	3.88
SPRAY	70	14.39	9.49

TABLE 4.21 Fuel Consumption in Field Operations (Litres/Acre), Essex Watershed

Operation	Number of Observations	Mean	S.D.
BALE	19	3.70	1.22
CHISEL PLOW	10	74.20	196.80
COMBINE	68	20.78	28.88
CULTIVATE	93	6.03	8.46
CUT	19	3.12	0.97
DISC	55	16.15	18.54
FERTILIZE	35	2.56	3.93
FURROW	21	0.80	1.55
HAUL	12	16.38	14.38
MOLDBOARD PLOW	49	23.82	28.79
PLANT	100	5.96	9.76
RAKE	21	1.58	0.83
SPRAY	79	4.60	9.54

4.2.6 Summary of Field Operation Coverage

APPENDIX II, TABLES II.1 to II.3 contain detailed information on the area covered for each of the kinds of operation related to each crop and in each year in both the test and control portions of each Pilot Watershed. This should provide an indication of the differences between test and control watersheds in terms of the kind and extent of operations actually performed. The tables were prepared using all available data (both that considered reliable and that considered unreliable) so anomalies are evident.

The area moldboard plowed as a percent of area planted is presented in TABLES 4.22, 4.23, and 4.24. This gives some indication of differences in crops and test/control watersheds in terms of the prevalence of moldboard plowing in field preparation. Examination of the appendix tables yields similar information for other operations such as cultivation, discing, and spraying but these are not discussed here.

Kettle

Moldboard plow use in field preparation for corn, soybean, and wheat crops was lower in the test watershed than in the control watershed; it decreased over the 1989 to 1991 period; and it is considerably less prevalent in wheat production than in corn or soybean production.

TABLE 4.22 Area Moldboard Plowed As A Percent Of Area Seeded, Kettle Watershed

Corn

Year	Control	Test
1989	43%	40%
1990	95%	78%
1991	56%	28%

Soybeans

Year	Control	Test
1989	49%	72%
1990	94%	48%
1991	26%	11%

Wheat

Year	Control	Test
1989	23%	0%
1990	42%	11%
1991	-	9%

Pittock

Moldboard plow use in field preparation for corn crops was lower in the test watershed than in the control watershed, and it decreased over the 1989 to 1991 period.

TABLE 4.23 Area Moldboard Plowed As A Percent Of Area Seeded, Pittock Watershed

Corn

Year	Control	Test
1989	113	101
1990	95	61
1991	89	81

Essex

In field preparation for a soybean crop, moldboard plow use was lower in the test watershed than in the control watershed. Percentages in excess of 100% in the test watershed infer that some fields were plowed more than once before planting. It is more likely that this anomaly is caused by over-reporting of moldboard plowing operations, or under-reporting of planting operations. The areas of corn and wheat are too small to permit reliable interpretation.

TABLE 4.24 Area Moldboard Plowed As A Percent Of Area Seeded, Essex Watershed

Soybeans

Year	Control	Test
1989	23%	160%
1990	53%	109%
1991	24%	46%

4.3 FINANCIAL MODELLING

The basic objective of the field data collection effort was to provide data required to carry out field level financial analysis. While the original intention was to base the financial analysis on all of the relevant field data collected, it became apparent as the collection and analysis of field data progressed that the PWs field data would not provide a reliable base for financial analysis.

Modifying the approach to financial analysis was essentially a three step process:

- A preliminary analysis of all the relevant data from the Kettle watershed led to the identification of a number of problems with

the data. This preliminary analysis for the Kettle watershed and a summary of the problems identified are discussed in the section 4.3.1 below.

- In an effort to circumvent data reliability problems the financial analysis was restricted to those crops for which the field data had been rated moderately or highly reliable, and in the case of "test" watersheds, where conservation tillage had been adopted or at least an "honest effort" made to do so. While this reduced variability in the data, it also reduced the number of crops available for analysis. Results of the analysis of restricted datasets for selected crop rotations are presented below.

- The analysis based on restricted datasets was still too variable to produce a reliable basis for cost comparisons between conventional and conservation practices. For many of the crop rotations for which comparisons were required few or even no observations could be obtained from the restricted dataset. Unusual circumstances such as planting corn twice in an unusually wet spring and replanting winter killed winter wheat to soybeans further complicated the analysis.

Because of these problems, a decision was made to take an alternate approach to developing estimates of net revenues. Rather than rely entirely on data from the Pilot Watersheds, "representative" operations were developed for production using conventional and soil conservation technologies based on results of the Tillage 2000 project and input from others involved in the SWEEP program who had had closer contact with farmers, as well as the PWs field data. The revised approach to preparing field budgets is described fully in Volume III, Field Level Economic Analysis.

4.3.1 Kettle

Results of the initial analysis for Kettle Creek, which included all available data, can be found in APPENDIX III. Because it became apparent that the data problems were common to all three pilot watersheds, no effort was made to carry out a similar analysis in the Pittock and Essex watersheds.

The results were not very satisfactory from a number of points of view. A few of the specific observations that raised suspicions about the quality of the results include:

- mean field preparation cost for corn following corn in the test watershed (conservation tillage) was $84.37/hectare, almost 60% above that in the control watershed (conventional tillage) at $53.05/hectare. This is in direct contradiction to what could be expected. Reduced effort in field preparation is the key feature of conservation tillage. It is also inconsistent with results obtained from the Tillage 2000 project.

- mean hours/hectare for conservation tillage (8.77 hrs/hectare) was more than 25% above that for conventional tillage corn following corn (6.86 hours/hectare). This also contradicts what could be expected given the nature of conservation tillage and is also inconsistent with results obtained from the Tillage 2000 project.

- mean yield for conservation tillage at 7.97 tonnes/hectare was over 20% above that for conventional tillage corn following corn at 6.45 tonnes/hectare. Tillage 2000 data and subjective assessments of the impact of conservation tillage on corn yields suggest that yield is about the same or perhaps slightly lower than under conventional tillage practices. Thus a yield increase of 20% is inconsistent with other evidence.

- there are glaring inconsistencies at several points. For instance the mean harvesting cost for conservation tillage corn following soybeans is $11.52 per hectare while the comparable cost under conventional tillage is $49.42. There is no reason to expect any difference between harvesting costs. Another example appears in the results for soybeans following soybeans where the subtotal for cost of conducting operations is higher for conventional ($183.14) than for conservation tillage ($147.04), while hours per hectare are lower for conventional (5.36 hrs) than for conservation tillage (5.69 hrs). Hours per hectare should correspond closely with machine costs unless there are major differences between groups in terms of investment in machinery.

Results of the same analysis applied to a restricted dataset (which excludes crops for which data reliability was considered low and test watershed crops with a low level of adoption) are presented in APPENDIX IV, TABLE IV.1. In the Kettle watershed this analysis was completed for a corn following corn rotation only. As with the analysis that included all data, the high degree of variability in all cost categories precludes useful and statistically valid conclusions about the relationship between costs of conservation and conventional tillage practices.

4.3.2 Pittock

In the Pittock watershed cost analysis based on a restricted dataset was completed for a corn following corn rotation only. Results are presented in APPENDIX IV, TABLE IV.2. As with the similar analysis in the Kettle watershed, the high degree of variability in all cost categories precludes useful and statistically valid conclusions about the relationship between costs of conservation and conventional tillage practices.

4.3.3 Essex

In the Essex watershed cost analysis based on a restricted dataset was completed for a soy following soy rotation only. There were no fields in this watershed with a corn following corn rotation and data reliable enough to qualify for the restricted dataset. Likewise, only four soy following wheat crops qualified for the restricted dataset.

Results for soy following soy are presented in APPENDIX IV, TABLE IV.3. Again, the high degree of variability in all cost categories precludes useful and statistically valid conclusions about the relationship between costs of conservation and conventional tillage practices.

5.0 CONCLUSIONS AND RECOMMENDATIONS

The effort to collect economic information in the pilot watersheds produced a large volume of data. Unfortunately the data could not provide a reliable basis for financial modelling at the field level and the subsequent economic analysis at the watershed level. It is important to clearly understand the reasons why the data proved unsuitable for the intended purpose so that similar problems can be avoided in future projects of this nature.

Perhaps the most important shortcoming of the data is the high degree of variability that it exhibits. Several sources of variability can be identified, some of which could have been better controlled through improved collection procedures, but most of which could only be effectively removed by modifying the experimental design. Some of the more important sources of variability are discussed in the following paragraphs.

Crop Management Practices

The data reflects a high degree of variability between farms and their operators in terms of cropping practices. This extends to herbicide use, fertility strategies, choice of seed, seeding date, and harvest practices as well as tillage practices. Machine costs are also highly variable: there are wide differences between farms in terms of investment in machinery, cost reduction strategies such as swapping/borrowing/renting between neighbours are prevalent, custom hiring is common in harvest operations, and harvesting of processing crops such as sweet corn and peas is often the responsibility of the processor. All of these factors make it very difficult to isolate the effect of tillage practices on both costs and yields (returns).

Weather

Year to year variability in weather is a problem for two reasons: the impact that weather has on yield, and changes in management practices in reaction to weather conditions. Weather impact on yield adds another variable that should be controlled in any analysis of costs and returns. Changes in management practices in reaction to weather conditions can have a significant impact on costs. Particular examples of this problem evident in the watershed data were situations in which a winter wheat crop was winter killed and a soybean crop was planted in the spring, and replanting corn crops after a severe rainstorm washed out much of the first seeding.

Reliability of Reporting

There was a wide variation in the reliability of data recording between co-operands. Some understood what was required and were very conscientious about measuring and/or recording operations and time, fuel, material, and machine use. Others were less conscientious. Problems related to reliability of reporting have been discussed extensively above.

Level of Adoption

Even in test watersheds only a portion of cropping activity involved what could be considered a complete adoption of conservation tillage practices. In a few cases conservation tillage practices were already in place. In others co-operands responded quickly to conservation tillage recommendations. Still others responded slowly or not at all. In addition, a portion of each test watershed was devoted to crops which were of limited interest in the economic analysis. These included processing crops such as sweet corn and peas, a variety of dry

beans, small grains, hay, and pasture. As a result, the number of examples of conservation tillage in a particular crop and watershed was limited.

Feedback

There were very limited opportunities to provide feedback of economic information, or even a summary of the data that they had supplied, to co-operands. This is very unsatisfactory from at least two points of view: it is very difficult to develop or maintain a satisfactory level of co-operation or involvement on the part of the co-operand, and as a result the quality of reporting suffers; and it is virtually impossible to correct errors or omissions found in the recorded data.

Responsibility, Authority, and Control

A decision was taken early in the life of the project that co-operands should not have to deal with more than one person for all matters related to the pilot watersheds. The watershed technicians employed by CMS became that contact.

While the idea that co-operands should not have to deal with more than one person was probably a good one, it had a number of serious implications for the economic analysis. The field technicians primary role, in the test watersheds at least, was to promote conservation tillage practices. This was not always consistent with ensuring that economic data was consistently and accurately recorded. The lack of direct authority/responsibility between the field technician and those responsible for the economic analysis rendered timely reporting and effective feedback virtually impossible. As a result the quality of the data finally available suffered.

The conclusions above suggest a number of measures that should be taken to avoid similar problems in future projects of this nature:

- The experiment should be designed to control as many variables as possible. Paired plots are an effective way of controlling a large number of variables (seed used, seeding date, fertility practices, other crop management practices, and weather). In experiments that involve differences in tillage practices under field conditions the plot sizes must necessarily be large. This may make it difficult to control differences in land characteristics between plots, but there are ways to minimize this problem. The experimental design used in the Tillage 2000 project (see Volume Four: An Economic Evaluation of the Tillage 2000 Program in Ontario) has a number of good features that should be kept in mind in designing future projects of this nature.

- The distinction between "test" and "control" should be clearly defined. The test portions of pilot watersheds contained a relatively small proportion of area on which conservation tillage practices had been completely implemented. Once again, a paired plot approach involving clearly defined differences between test and control plots would alleviate this problem.

- The scope of data collection should be carefully focused and at the same time the rigor of data collection should be ensured. In this experiment a substantial quantity of information was collected that was not ultimately used. There were serious shortcomings in the quality of certain aspects of the data that was collected, particularly related to labour and fuel requirements.

- Prompt feedback to co-operands is essential. This project clearly demonstrated that an inability to provide prompt feedback to co-operands and to correct errors and omissions immediately in consultation with co-operands will produce data of questionable quality. Consideration should also be given to identifying those co-operands who are willing and able to provide sound data, concentrate on obtaining data from them, and discontinue efforts with co-operands who provide poor data. Careful consideration should also be given to providing assistance to co-operands for critical or difficult measurements such as fuel use. This may involve providing special measuring devices, assistance with measurement and recording, or even making measurement and recording entirely the responsibility of project personnel rather than the co-operand.

In spite of the problems identified above, the economic data collected in the PWs did provide critical input into the field level economic analysis. The method of cost analysis embodied in the costing program provides a prototype for economic analysis of field data which has been proven effective in dealing with both the Tillage 2000 and the Pilot Watersheds data.

APPENDIX I

COST REPORT

A PASCAL LANGUAGE PROGRAM

```
program cost_rep;

const
  d_price = 0.40;
  g_price = 0.50;
  acres = 1;
  yield = 2;
  prep = 3;
  plant = 4;
  grow = 5;
  harv = 6;
  seed = 7;
  fert = 8;
  herb = 9;
  inse = 10;
  fuel = 11;
  hours = 12;

type
  str5 = string[5];
  str63 = string[63];

  fmrec = record
    farm:string[4];
    id:integer;
    name:string[20];
    ta,ca:real;
    au:string[2];
    ws:string[8];
    end;

  fdrec = record
    farm:string[4];
    field:string[3];
    area:real;
    au:string[2];
    group:char;
    end;

  oprec = record
    farm:string[4];
    field:string[3];
    date:string[6];
    opnum:char;
```

```
crop:string[3];
opclass:char;
opkind:string[5];
cover:integer;
person:char;
time:real;
fuel:real;
fu,ft,fe:char;
loc:string[6];
mach:string[32];
end;

cmrec = record
  farm:string[4];
  field:string[3];
  date:string[6];
  opnum:char;
  name:string[14];
  rate:real;
  ru:string[2];
  end;

mtrec = record
  farm:string[4];
  field:string[3];
  date:string[6];
  opnum:char;
  typ:char;
  desc:string[6];
  brand:string[15];
  anal:string[12];
  rate:real;
  ru:string[3];
  end;

obfrec = record
  key:string[16];
  group:char;
  sum:array[1..12] of real;
  end;

defrec = record
  op:string[5];
  d,g,t:real;
```

```
  end;

p_mi = ^mirec;
mirec = record
  farm:string[4];
  mach:string[4];
  typ:string[15];
  brand:string[12];
  desc:string[20];
  hp:integer;
  fuel:char;
  width:real;
  uw:string[4];
  mfg:integer;
  pm:real;
  class:string[5];
  anhrs:integer;
  rm:real;
  cost:real;
  next:p_mi;
  end;

p_mat = ^matrec;
matrec = record
  typ:char;
  brand:string[15];
  desc:string[6];
  anal:string[12];
  price:real;
  up:string[2];
  next:p_mat;
  end;

var
  er:integer;
  c:char;
  x:real;
  s,fmin,fdin,opin,cmin,mtin:string[255];
  reportkey,prevreportkey:string[16];
  opkey,mhkey,mtkey,cmkey:string[16];
  mach:string[4];
  modstr:str63;
  obf:array[1..2] of obfrec;
  defs:array[0..18] of defrec;
```

```
fm:fmrec;
fd:fdrec;
op:oprec;
cm:cmrec;
mt:mtrec;
mi,firstmi:p_mi;
mat,firstmat:p_mat;
found,morefm,morefd,moreop,moremt:boolean;
fm_f,fd_f,op_f,cm_f,mt_f,infil,outfil,erfil:text;

procedure getafarm;
 begin
 readln(fm_f,fmin);
 with fm do
  begin
  farm:=copy(fmin,1,4);
  val(copy(fmin,5,3),id,er);
  if er <> 0 then writeln(erfil,'error: invalid id in >',fmin);
  name:=copy(fmin,8,20);
  val(copy(fmin,28,6),ta,er);
  if er <> 0 then writeln(erfil,'error: invalid ta in >',fmin);
  val(copy(fmin,34,6),ca,er);
  if er <> 0 then writeln(erfil,'error: invalid ca in >',fmin);
  au:=copy(fmin,40,2);
  ws:=copy(fmin,42,8);
  end;
 end;

procedure getafield;
 begin
 readln(fd_f,fdin);
 with fd do
  begin
  farm:=copy(fdin,1,4);
  field:=copy(fdin,5,3);
  val(copy(fdin,8,6),area,er);
  if er <> 0 then writeln(erfil,'error: invalid area in >',fdin);
  au:=copy(fdin,14,2);
  group:=fdin[16];
  end;
 end;

procedure getanop;
 begin
```

```
readln(op_f,opin);
with op do
  begin
  farm:=copy(opin,1,4);
  field:=copy(opin,5,3);
  date:=copy(opin,8,6);
  opnum:=opin[14];
  crop:=copy(opin,15,3);
  opclass:=opin[18];
  opkind:=copy(opin,19,5);
  val(copy(opin,24,3),cover,er);
  if er <> 0 then writeln(erfil,'error: invalid coverage in >',opin);
  person:=opin[27];
  val(copy(opin,28,5),time,er);
  if er <> 0 then writeln(erfil,'error: invalid time in >',opin);
  val(copy(opin,33,5),fuel,er);
  if er <> 0 then writeln(erfil,'error: invalid fuel in >',opin);
  fu:=opin[38];
  ft:=opin[39];
  fe:=opin[40];
  loc:=copy(opin,41,6);
  mach:=copy(opin,47,32);
  end;
 opkey:=op.farm+op.field+op.date+op.opnum;
 end;

procedure getacm;
 begin
 readln(cm_f,cmin);
 with cm do
  begin
  farm:=copy(cmin,1,4);
  field:=copy(cmin,5,3);
  date:=copy(cmin,8,6);
  opnum:=cmin[14];
  name:=copy(cmin,15,14);
  val(copy(cmin,29,6),rate,er);
  if er <> 0 then writeln(erfil,'error: invalid rate in >',cmin);
  ru:=copy(cmin,35,2);
  end;
 cmkey:=cm.farm+cm.field+cm.date+cm.opnum;
 end;

procedure getamat;
```

```
begin
readln(mt_f,mtin);
with mt do
  begin
  farm:=copy(mtin,1,4);
  field:=copy(mtin,5,3);
  date:=copy(mtin,8,6);
  opnum:=mtin[14];
  typ:=mtin[15];
  desc:=copy(mtin,16,6);
  brand:=copy(mtin,22,15);
  anal:=copy(mtin,37,12);
  val(copy(mtin,49,8),rate,er);
  if er <> 0 then writeln(erfil,'error: invalid rate in >',mtin);
  ru:=copy(mtin,57,3);
  end;
mtkey:=mt.farm+mt.field+mt.date+mt.opnum;
end;

procedure readmi;
 var
  er:integer;
  dep,fin,hins,repair:real;
  inlin:string[255];
  prev:p_mi;
  first:boolean;
 begin
  assign(infil,'MI.TXT');
  reset(infil);
  firstmi:=nil;
  first:=true;
  while not eof(infil) do
    begin
    new(mi);
    readln(infil,inlin);
    with mi^ do
      begin
      farm:=copy(inlin,1,4);
      mach:=copy(inlin,5,4);
      typ:=copy(inlin,9,15);
      brand:=copy(inlin,24,12);
      desc:=copy(inlin,36,20);
      val(copy(inlin,56,3),hp,er);
      if er <> 0 then writeln(erfil,'error: invalid HP in >',inlin);
```

```
fuel:=inlin[59];
val(copy(inlin,60,5),width,er);
if er <> 0 then writeln(erfil,'error: invalid width in >',inlin);
uw:=copy(inlin,65,4);
val(copy(inlin,69,4),mfg,er);
if er <> 0 then writeln(erfil,'error: invalid yr mfg in >',inlin);
val(copy(inlin,73,6),pm,er);
if er <> 0 then writeln(erfil,'error: invalid pr mkt in >',inlin);
class:=copy(inlin,79,5);
val(copy(inlin,84,5),anhrs,er);
if er <> 0 then writeln(erfil,'error: invalid annual hrs in >',inlin);
if class = 'TRACT' then rm:=0.09
  else if class = 'TILL ' then rm:=0.48
  else if class = 'SEED ' then rm:=0.50
  else if class = 'FERT ' then rm:=1.00
  else if class = 'SPRAY' then rm:=0.83
  else if class = 'MOWER' then rm:=0.60
  else if class = 'FORAG' then rm:=0.40
  else if class = 'RAKE ' then rm:=0.40
  else if class = 'BALER' then rm:=0.32
  else if class = 'COMB ' then rm:=0.30
  else if class = 'DRYER' then rm:=0.24
  else if class = 'SPRED' then rm:=0.24
  else if class = 'AUGER' then rm:=0.32
  else if class = 'WAGON' then rm:=0.20
  else if class = 'OTH10' then rm:=0.45
  else if class = 'OTH15' then rm:=0.65
  else writeln(erfil,'error: class of machine not found in >',inlin);
if (class = 'TRACT') or (class = 'COMB') then
  begin
  dep:=(pm-0.25*pm)/10;
  fin:=((pm+0.25*pm)/2)*0.10;
  end
else
  begin
  dep:=(pm-0.10*pm)/15;
  fin:=((pm+0.10*pm)/2)*0.10;
  end;
hins:=pm*0.015;
cost:=(dep+fin+hins)/anhrs;
repair:=(pm/1000)*rm;
cost:=cost+repair;
end;
if first then
```

```
          begin
          firstmi:=mi;
          first:=false;
          end
        else
          prev^.next:=mi;
        prev:=mi;
        end;
        mi^.next:=nil;
      close(infil);
    end;

procedure readmat;
  var
    er:integer;
    inlin:string[255];
    prev:p_mat;
    first:boolean;
  begin
    assign(infil,'MATLST.TXT');
    reset(infil);
    firstmat:=nil;
    first:=true;
    while not eof(infil) do
      begin
      new(mat);
      readln(infil,inlin);
      with mat^ do
        begin
        typ:=inlin[1];
        brand:=copy(inlin,2,15);
        desc:=copy(inlin,17,6);
        anal:=copy(inlin,23,12);
        val(copy(inlin,35,7),price,er);
        if er <> 0 then writeln(erfil,'error: invalid price in >',inlin);
        up:=copy(inlin,42,2);
        end;
      if first then
        begin
        firstmat:=mat;
        first:=false;
        end
      else
        prev^.next:=mat;
```

```
    prev:=mat;
    end;
    mat^.next:=nil;
   close(infil);
  end;

procedure readdef;
  var
   i:integer;
  begin
  assign(infil,'DEFAULT.TXT');
  reset(infil);
  for i:=0 to 18 do
    with defs[i] do
      readln(infil,op,d,g,t);
  close(infil);
  end;

 function fuelcost:real;
  var
  i,k:integer;
  p,q,x,y,area:real;
  xdef:boolean;

  begin
  k:=0;
  for i:=1 to 18 do
    if copy(op.opkind,1,5) = defs[i].op then k:=i;
  p:=0.0;q:=0.0;
  xdef:=false;
  case op.ft of
    'D':begin
        p:=d_price;
        x:=defs[k].d;
        xdef:=true;
        end;
    'G':begin
        p:=g_price;
        x:=defs[k].g;
        xdef:=true;
        end;
    else writeln(erfil,'error: invalid fuel type ',opin);
    end;
   case op.fu of
```

```
    'G':q:=4.545*op.fuel;
    'L':q:=op.fuel;
    else writeln(erfil,'error: invalid fuel unit ',opin);
    end;
  area:=fd.area*op.cover/100;
  if area > 0.0 then
    begin
    y:=q/area;
    if xdef then
      if (y < 0.5*x) or (y > 1.5*x) then
        begin
        q:=x*area;
{       writeln(erfil,'warning: fuel default',q:5:1,' litres used >>',opin);
}
        end;
    end
  else
    writeln(erfil,'error: no area covered',opin);
  fuelcost:=1.15*p*q;          { add 15 % for lubrication costs }
  end;

procedure checktime;
  var
    i,k:integer;
    x,y,area:real;
  begin
  k:=0;
  for i:=1 to 18 do
    if copy(op.opkind,1,5) = defs[i].op then k:=i;
  x:=defs[i].t;
  area:=fd.area*op.cover/100;
  if op.time > 0.0 then
    y:=area/op.time
  else
    y:=0.0;
  if (y < 0.5*x) or (y > 1.5*x) then
    begin
    op.time:=area/x;
{   writeln(erfil,'warning: time default',op.time:5:1,' used >>',opin); }
    end;
  end;

function matcost(p:real;pu:str5;r:real;ru:str5;s:str63):real;
  var
```

```
  x,area,buf,mtf:real;
  subs:str63;

begin
area:=fd.area*op.cover/100;
pu:=copy(pu+'  ',1,2);
ru:=copy(ru+'   ',1,3);
x:=0.0;
case s[1] of
 'S': begin
    subs:=copy(s,2,6);
    buf:=1.0;
    if  (subs = 'WWHEAT') or (subs = 'SOY   ')
     or (subs = 'ALF   ') or (subs = 'CLOVER')
     or (subs = 'BIRDS ') or (subs = 'FLDPEA')
     then buf:=60.0
    else if  (subs = 'CORN  ') or (subs = 'RYE   ')
     or (subs = 'FLAX  ')
     then buf:=56.0
    else if (subs = 'RAPE  ') or (subs = 'SORG  ') then buf:=50.0
    else if (subs = 'BARLEY') or (subs = 'BUCK  ') then buf:=48.0
    else if subs = 'MIXEDG' then buf:=40.0
    else if subs = 'OATS  ' then buf:=34.0
    else writeln(erfil,'error: invalid seed type >>',mtin);
    if ru = 'BUA' then
     if pu = 'BU' then x:=r*area*p
     else if pu = 'U ' then x:=r*area*p
     else writeln(erfil,'error: bushel rate not matched >>',mtin)
    else if ru = 'MTA' then
     if pu = 'MT' then x:=r*area*p
     else if pu = 'KG' then x:=r*area*p/1000
     else writeln(erfil,'error: metric ton rate not matched >>',mtin)
    else if ru = 'LBA' then
     if pu = 'KG' then x:=r*area*p/2.2046
     else if pu = 'MT' then x:=r*area*p/2204.6
     else if pu = 'BU' then x:=r*area*p/buf
     else writeln(erfil,'error: lb rate not matched >>',mtin)
    else if ru = 'SDA' then
     if pu = 'BU' then x:=r/85000*area*p
     else if pu = 'U ' then x:=r/80000*area*p
     else writeln(erfil,'error: seed rate not matched >>',mtin)
    else if ru = 'KGA' then
      if pu = 'KG' then x:=r*area*p
      else if pu = 'MT' then x:=r*area*p/1000
```

```
    else writeln(erfil,'error: kg rate not matched >>',mtin)
    end;
 'H','I','F':
    begin
    if ru = 'GLA' then
     if pu = 'GL' then x:=r*area*p
     else if pu = 'LT' then x:=r*area*p*4.546
     else if pu = 'MT' then
      begin
      subs:=copy(s,1,15);
      if subs = 'FLIQUIDNITROGEN' then
       x:=r*area*p/171.85
      else
       writeln(erfil,'error: gallon rate not matched >>',mtin);
      end
     else writeln(erfil,'error: gallon rate not matched >>',mtin)
    else if ru = 'LTA' then
     if pu = 'LT' then x:=r*area*p
     else if pu = 'GL' then x:=r*area*p/4.546
     else writeln(erfil,'error: litre rate not matched >>',mtin)
    else if ru = 'LTH' then
     if pu = 'LT' then x:=r/2.46*area*p
     else if pu = 'GL' then x:=r/2.46*area*p/4.546
     else writeln(erfil,'error: litre rate not matched >>',mtin)
    else if ru = 'MTA' then
     if pu = 'MT' then x:=r*area*p
     else if pu = 'KG' then x:=r*area*p/1000
     else writeln(erfil,'error: metric ton rate not matched >>',mtin)
    else if ru = 'LBA' then
     if pu = 'KG' then x:=r*area*p/2.2046
     else if pu = 'MT' then x:=r*area*p/2204.6
     else if pu = 'BU' then x:=r*area*p/56.0
     else writeln(erfil,'error: lb rate not matched >>',mtin)
    else if ru = 'OZA' then
     if pu = 'KG' then x:=r*area*p/35.273
     else writeln(erfil,'error: oz rate not matched >>',mtin)
    else if ru = 'KGA' then
     if pu = 'KG' then x:=r*area*p
     else if pu = 'MT' then x:=r*area*p/1000
     else writeln(erfil,'error: kg rate not matched >>',mtin)
    else if ru = 'GMA' then
     if pu = 'GM' then x:=r*area*p
     else if pu = 'KG' then x:=r*area*p/1000
     else writeln(erfil,'error: gram rate not matched >>',mtin)
```

```
    else if ru = 'MLA' then
      if pu = 'LT' then x:=r*area*p/1000
      else writeln(erfil,'error: millilitre rate not matched >>',mtin)
    else if ru = 'PK ' then
      if pu = 'PK' then x:=r*p
      else writeln(erfil,'error: packet rate not matched >>',mtin)
    else writeln(erfil,'error: invalid rate unit >>',mtin);
    end;
  'Y': begin             {NOTE: this calculates yield NOT revenue}
    subs:=copy(s,2,6);
    mtf:=1.0;
    if subs = 'CORN  ' then mtf:=39.368
    else if subs = 'SOY   ' then mtf:=36.744
    else if subs = 'WWHEAT' then mtf:=36.744
    else if subs = 'HAY   ' then mtf:=1
    else writeln(erfil,'error: invalid crop code >>',mtin);
    if ru = 'BUA' then x:=(r/mtf)*area
    else if ru = 'MTA' then x:=r*area
    else if ru = 'BLA' then x:=r*area
    else if ru = 'BU ' then x:=r/mtf
    else if ru = 'MT ' then x:=r
    else if ru = 'BL ' then x:=r
    else writeln(erfil,'error: invalid yield rate >>',mtin);
    end;
  else writeln(erfil,'error: invalid material type >>',mtin);
  end;
matcost:=x;
end;

procedure zerobf(i:integer);
var k:integer;
begin
with obf[i] do
  begin
  key:='';
  group:=' ';
  for k:=1 to 12 do
    sum[k]:=0.0;
  end;
end;

procedure writebf(i:integer);
var k:integer;
begin
```

```
with obf[i] do
  begin
  write(outfil,'"',copy(key,1,7),'" "',copy(key,8,3),'" "',group,'"');
  for k:=1 to 12 do
    write(outfil,sum[k]:10:2);
  writeln(outfil);
  end;
end;

procedure accumbf(k:integer;x:real);
begin
if reportkey = obf[1].key then
  case k of
    1:obf[1].sum[k]:=x;
    2:if abs(obf[1].sum[k]) > 0.01 then
        begin
        writeln(erfil,'warning: multiple yields >>',mtin);
        obf[1].sum[k]:=obf[1].sum[k]+x;
        end
      else
        obf[1].sum[k]:=x;
    3..12:obf[1].sum[k]:=obf[1].sum[k]+x;
    end
else if reportkey = obf[2].key then
  case k of
    1:obf[2].sum[k]:=x;
    2:if abs(obf[2].sum[k]) > 0.01 then
        begin
        writeln(erfil,'warning: multiple yields >>',mtin);
        obf[2].sum[k]:=obf[2].sum[k]+x;
        end
      else
        obf[2].sum[k]:=x;
    3..12:obf[2].sum[k]:=obf[2].sum[k]+x;
    end
else
  begin
  if obf[1].key > '' then writebf(1);
  obf[1]:=obf[2];
  zerobf(2);
  obf[2].key:=reportkey;
  obf[2].group:=fd.group;
  case k of
    1,2:obf[2].sum[k]:=x;
```

```
    3..12:obf[2].sum[k]:=obf[2].sum[k]+x;
    end;
   end;
  end;

begin          { ******* execution begins here ******* }
assign(erfil,'ERR.TXT');
rewrite(erfil);
readmi;
readmat;
readdef;
assign(fm_f,'FARM.SET');
reset(fm_f);
morefm:=true;
if eof(fm_f) then morefm:=false else getafarm;
assign(fd_f,'FIELD.SET');
reset(fd_f);
morefd:=true;
if eof(fd_f) then morefd:=false else getafield;
assign(op_f,'OPER.SET');
reset(op_f);
moreop:=true;
if eof(op_f) then moreop:=false else getanop;
assign(cm_f,'CUSTOM.SET');
reset(cm_f);
assign(mt_f,'MAT.SET');
reset(mt_f);
moremt:=true;
if eof(mt_f) then moremt:=false else getamat;
assign(outfil,'OUT.TXT');
rewrite(outfil);
zerobf(1);
zerobf(2);
while morefm do
  begin
  if fd.farm > fm.farm then writeln(erfil,'  error: no fields');
  while morefd and (fd.farm = fm.farm) do
    begin
    if (op.farm = fd.farm) and (op.field > fd.field) then
      writeln(erfil,'    no operations >>',fd.farm,fd.field);
    while moreop and (op.farm+op.field = fd.farm+fd.field) do
      begin
      {operation information is available}
      reportkey:=fm.farm+fd.field+op.crop;
```

```
        accumbf(acres,fd.area);
        if op.person <> 'C' then
          begin
          checktime;
          accumbf(hours,op.time);
          accumbf(fuel,fuelcost);
          end
        else
          begin
          getacm;
          if cmkey <> opkey then writeln(erfil,'error: custom does not
match operation >>',cmkey);
          if cm.ru = 'AC' then
            begin
            x:=fd.area*cm.rate;
{           writeln(outfil,x:8:2);        } {custom costs}
            case op.opclass of
              'P':accumbf(prep,x);
              'L':accumbf(plant,x);
              'G':accumbf(grow,x);
              'H':accumbf(harv,x);
              else writeln(erfil,'error: invalid operation code ',op.opclass);
              end;
            end
          else writeln(erfil,'error: custom unit is not acres',cmin);
          end;

        s:=op.mach;
        while length(s) > 0 do
          begin
          mach:=copy(s,1,4);
          mach:=copy(mach+'    ',1,4);
          delete(s,1,4);
          {find machine in the inventory}
          found:=false;
          mi:=firstmi;
          while not found and (mi <> nil) do
            if mi^.farm+mi^.mach = op.farm+mach then
              found:=true
            else
              mi:=mi^.next;
          if found then
            begin               {mi points to machine information}
            x := mi^.cost*op.time;
```

```
{       WRITELN(outfil,x:10:2);                 }
        case op.opclass of
          'P':accumbf(prep,x);
          'L':accumbf(plant,x);
          'G':accumbf(grow,x);
          'H':accumbf(harv,x);
          else writeln(erfil,'error: invalid operation code ',op.opclass);
          end;
        end
      else
        writeln(erfil,'      >',mach,'<  no machine in inventory',opin);
      end;

    while moremt and (mtkey = opkey) do
      begin
      {material rate info is available in record mt}
      modstr:=mt.typ+mt.desc+mt.brand+mt.anal;
      {find material in the list}
      found:=false;
      mat:=firstmat;
      while not found and (mat <> nil) do
        if modstr = mat^.typ+mat^.desc+mat^.brand+mat^.anal then
          found:=true
        else
          mat:=mat^.next;
      if found then
        begin
        {mat points to material price information}
        x:=matcost(mat^.price,mat^.up,mt.rate,mt.ru,modstr);
        case mat^.typ of
          'F':accumbf(fert,x);
          'H':accumbf(herb,x);
          'I','T':accumbf(inse,x);
          'S':accumbf(seed,x);
          'Y':accumbf(yield,x);
          end;
{     writeln(outfil,mt.typ,mt.brand,mt.desc,mt.anal,mt.rate:6:1,mt.ru,
              mat^.price:6:2,mat^.up,x:10:2);          }
        end
      else
        writeln(erfil,mt.typ+mt.brand+mt.desc+mt.anal,
                '  material not in list');

      if eof(mt_f) then moremt:=false else getamat;
```

```
      end;
    while moremt and (mtkey < opkey) do
      begin
      writeln(erfil,'       error: no operation for material >',mtin);
      if eof(mt_f) then moremt:=false else getamat;
      end;

    if eof(op_f) then moreop:=false else getanop;
    end;
  while moreop and (op.farm+op.field < fd.farm+fd.field) do
    begin
    writeln(erfil,'    error: no farm/field for operation >',opin);
    if eof(op_f) then moreop:=false else getanop;
    end;

  if eof(fd_f) then morefd:=false else getafield;
  end;
 while morefd and (fd.farm < fm.farm) do
  begin
  writeln(erfil,'error: no farm for field >',fdin);
  if eof(fd_f) then morefd:=false else getafield;
  end;
 if eof(fm_f) then morefm:=false else getafarm;
 end;
close(fm_f);
close(fd_f);
close(op_f);
close(cm_f);
close(mt_f);
writebf(1);
writebf(2);
close(outfil);
close(erfil);
end.
```

APPENDIX II

OPERATION COVERAGE

IN

CONTROL AND TEST WATERSHEDS

Table II.1 Operation Coverage on Corn Crops in the Kettle Watershed

	# of Operations			Acres Covered		
	1989	1990	1991	1989	1990	1991
CHIS						
Control	2	-	-	45.00	-	-
Test	2	2	6	30.00	9.80	119.40
CHOP						
Control	1	1	-	16.00	16.00	-
Test	-	3	3	-	2.50	2.50
COMB						
Control	15	13	20	193.80	329.00	468.60
Test	12	12	16	154.00	165.70	222.80
CULT						
Control	25	24	24	466.60	982.00	748.30
Test	26	25	26	488.00	343.20	525.50
CUT						
Control	-	-	-	-	-	-
Test	-	-	2	-	-	20.00
DISC						
Control	5	3	5	139.20	78.50	146.20
Test	6	2	4	53.00	40.00	74.00
FERT						
Control	12	17	18	249.50	599.00	431.00
Test	16	19	26	212.50	232.20	358.00
HAUL						
Control	1	-	3	11.90	-	51.00
Test	2	-	-	26.00	-	-
MOLD						
Control	8	16	11	126.40	442.00	232.70
Test	9	8	6	77.00	137.20	87.60
PACK						
Control	3	1	1	65.00	45.00	15.00
Test	2	1	1	8.00	5.00	2.50
PICK						
Control	-	1	-	-	16.00	-
Test	2	-	-	17.00	-	-
PLANT						
Control	14	15	19	292.40	464.00	413.70
Test	13	12	21	189.00	175.20	309.30
RHOE						
Control	2	2	-	40.00	66.00	-
Test	-	3	-	-	45.20	-
ROWC						
Control	1	5	6	11.90	136.00	89.60
Test	6	6	9	93.00	74.00	158.00
SPRAY						
Control	16	12	22	291.10	376.50	597.70
Test	17	21	37	222.70	283.80	491.60

Table II.2 Operation Coverage on Soybean Crops in the Kettle Watershed

	# of Operations			Acres Covered		
	1989	1990	1991	1989	1990	1991
CHIS						
Control	1	1	-	36.00	10.00	-
Test	3	5	2	53.00	67.40	50.00
COMB						
Control	8	3	10	166.00	43.00	171.60
Test	17	18	14	291.00	291.40	154.20
CULT						
Control	15	10	17	260.20	257.00	630.20
Test	52	33	12	1,074.60	641.00	364.80
DISC						
Control	2	-	-	62.00	-	-
Test	6	5	4	137.00	76.30	98.00
FERT						
Control	5	6	6	94.00	85.30	152.00
Test	10	6	6	137.80	81.00	101.20
HAUL						
Control	1	-	-	17.00	-	-
Test	-	1	3	-	13.00	43.00
MOLD						
Control	5	5	3	72.40	84.00	51.00
Test	14	12	4	290.40	149.70	24.10
PACK						
Control	-	-	1	-	-	24.00
Test	4	2	1	28.00	11.00	7.00
PICK						
Control	-	-	-	-	-	-
Test	1	-	3	26.00	-	85.00
PLANT						
Control	7	4	13	147.20	89.00	193.10
Test	21	19	17	402.00	308.60	226.00
RHOE						
Control	1	1	-	10.00	5.40	-
Test	1	1	-	26.00	16.00	-
ROWC						
Control	1	2	3	17.00	50.00	48.00
Test	2	1	3	16.00	26.00	58.20
SPRAY						
Control	7	5	11	172.30	81.00	223.00
Test	27	23	24	489.80	335.70	357.10
STONE						
Control	-	-	1	-	-	10.60
Test	-	1	-	-	7.00	-

Table II.3 Operation Coverage on Wheat Crops in the Kettle Watershed

	# of Operations			Acres Covered		
	1989	1990	1991	1989	1990	1991
BALE						
Control	-	-	-	-	-	-
Test	1	-	2	12.00	-	6.50
CHIS						
Control	-	1	-	-	23.00	-
Test	1	3	1	11.00	47.40	35.00
COMB						
Control	7	4	-	124.00	85.00	-
Test	6	8	16	55.20	98.00	222.90
CULT						
Control	12	4	-	72.00	72.00	-
Test	7	13	3	204.40	204.40	81.00
DISC						
Control	-	4	-	-	126.00	-
Test	2	3	2	22.00	19.00	17.30
FERT						
Control	7	6	-	311.30	117.00	-
Test	5	8	16	58.00	107.40	271.20
HAUL						
Control	-	1	-	-	17.00	-
Test	-	-	2	-	-	26.00
MOLD						
Control	1	3	-	23.00	64.00	-
Test	-	2	3	-	24.00	17.50
PACK						
Control	-	-	-	-	-	-
Test	-	1	1	-	3.40	0.60
PICK						
Control	-	-	-	-	-	-
Test	-	3	-	-	61.00	-
PLANT						
Control	3	10	-	98.00	152.30	-
Test	6	17	14	59.00	207.40	194.90
RHOE						
Control	-	-	-	-	-	-
Test	-	-	-	-	-	-
ROWC						
Control	-	-	-	-	-	-
Test	-	-	-	-	-	-
SPRAY						
Control	-	-	-	-	-	-
Test	3	5	1	21.20	93.00	14.00
STONE						
Control	-	-	-	-	-	-
Test	-	1	1	-	25.00	11.00

Table II.4 Operation Coverage on Corn Crops in the Pittock Watershed

	# of Operations			Acres Covered		
	1989	1990	1991	1989	1990	1991
BALE						
Control	-	-	1	-	-	9.00
Test	-	-	-	-	-	-
BLOW						
Control	-	-	-	-	-	-
Test	-	-	1	-	-	15.00
CHIS						
Control	-	-	-	-	-	-
Test	-	2	2	-	31.20	32.00
CHOP						
Control	-	-	-	-	-	-
Test	5	3	6	46.10	24.00	65.00
CMUL						
Control	-	-	-	-	-	-
Test	-	2	-	-	52.00	-
COMB						
Control	32	29	28	353.00	282.00	245.40
Test	13	22	22	91.60	300.00	320.00
CONS						
Control	-	-	-	-	-	-
Test	-	2	1	-	28.00	14.00
CULT						
Control	23	24	28	384.80	425.40	526.40
Test	28	28	37	329.90	439.00	624.20
DISC						
Control	8	5	5	133.00	88.00	67.10
Test	8	13	6	97.00	156.00	72.00
FERT						
Control	21	19	28	298.20	207.00	489.00
Test	10	11	14	86.20	190.00	196.00
FRICK						
Control	-	-	1	-	-	1.90
Test	-	-	-	-	-	-
HAND						
Control	-	-	-	-	-	-
Test	-	1	-	-	0.00	-

Table II.4 Operation Coverage on Corn Crops in the Pittock Watershed (Cont'd)

	# of Operations			Acres Covered		
	1989	1990	1991	1989	1990	1991
HARR						
Control	9	6	4	158.00	134.00	95.10
Test	-	-	-	-	-	-
HARV						
Control	1	1	-	15.00	3.00	-
Test	-	-	-	-	-	-
HAUL						
Control	17	20	18	133.00	193.40	140.20
Test	4	1	5	33.30	9.00	53.00
IRRG						
Control	-	-	-	-	-	-
Test	-	-	2	-	-	14.00
MANUR						
Control	-	-	-	-	-	-
Test	1	2	1	9.00	18.00	22.00
MOLD						
Control	21	19	17	331.70	277.00	346.20
Test	23	13	23	206.40	195.00	281.80
MULC						
Control	3	2	-	23.10	42.00	-
Test	4	1	-	36.00	9.00	-
PACK						
Control	3	7	9	29.00	61.00	165.00
Test	3	5	2	34.90	81.00	18.00
PICK						
Control	-	-	-	-	-	-
Test	1	-	1	12.00	-	12.00
PLANT						
Control	21	19	19	291.60	292.10	390.10
Test	20	24	31	204.00	319.00	346.00
RAKE						
Control	-	-	-	-	-	-
Test	-	-	2	-	-	14.00
RHOE						
Control	-	-	-	-	-	-
Test	1	4	1	12.00	37.50	3.00
ROWC						
Control	3	2	1	32.00	41.00	15.00
Test	6	5	8	68.90	45.20	63.00

Table II.4 Operation Coverage on Corn Crops in the Pittock Watershed (Cont'd)

	# of Operations			Acres Covered		
	1989	1990	1991	1989	1990	1991
SAVE						
Control	-	-	-	-	-	-
Test	1	-	-	17.00	-	-
SHRED						
Control	4	4	5	98.00	98.00	98.00
Test	-	-	-	-	-	-
SPRAY						
Control	27	27	31	432.40	519.20	659.30
Test	17	36	35	201.00	592.00	574.00
STONE						
Control	1	4	3	31.00	76.00	57.00
Test	-	2	-	-	27.00	-
TILL						
Control	-	-	-	-	-	-
Test	-	2	-	-	49.00	-

Table II.5 Operation Coverage on Soybean Crops in the Pittock Watershed

	# of Operations			Acres Covered		
	1989	1990	1991	1989	1990	1991
BALE						
Control	-	-	-	-	-	-
Test	1	-	-	0.00	-	-
COMB						
Control	1	-	2	24.00	-	17.00
Test	8	2	4	42.90	35.00	66.00
CULT						
Control	4	-	-	96.00	-	-
Test	4	4	5	110.00	99.00	76.00
CUT						
Control	-	-	-	-	-	-
Test	1	-	-	0.00	-	-
DISC						
Control	1	-	2	24.00	-	17.00
Test	2	4	4	0.00	46.00	66.00
FERT						
Control	1	-	-	24.00	-	-
Test	-	2	-	-	26.00	-
HAUL						
Control	-	-	-	-	-	-
Test	1	-	-	9.60	-	-
MANUR						
Control	-	-	-	-	-	-
Test	-	1	-	-	19.00	-
MOLD						
Control	1	-	3	24.00	-	22.00
Test	4	3	2	57.40	37.40	24.00
PACK						
Control	-	-	4	-	-	34.00
Test	-	-	2	-	-	28.00
PLANT						
Control	1	-	2	24.00	-	17.00
Test	4	3	2	61.00	45.00	44.00
PULL						
Control	-	-	-	-	-	-
Test	4	-	-	19.60	-	-

Table II.5 Operation Coverage on Soybean Crops in the Pittock Watershed (Cont'd)

	# of Operations			Acres Covered		
	1989	1990	1991	1989	1990	1991
RHOE						
Control	-	-	-	-	-	-
Test	1	-	-	12.00	-	-
ROCKS						
Control	-	-	-	-	-	-
Test	-	1	-	-	16.00	-
ROWC						
Control	-	-	-	-	-	-
Test	2	2	2	12.00	17.30	25.00
SPRAY						
Control	4	-	6	84.00	-	46.80
Test	5	6	4	49.00	96.00	66.00
STONE						
Control	-	-	-	-	-	-
Test	-	1	-	-	10.00	-
TILL						
Control	-	-	-	-	-	-
Test	-	1	-	-	19.00	-
WIND						
Control	-	-	-	-	-	-
Test	3	-	-	9.60	-	-

Table II.6 Operation Coverage on Wheat Crops in the Pittock Watershed

	# of Operations			Acres Covered		
	1989	1990	1991	1989	1990	1991
BALE						
Control	-	3	3	-	25.60	16.00
Test	-	-	1	-	-	5.00
CHIS						
Control	1	-	-	1.20	-	-
Test	3	2	-	34.00	29.00	-
COMB						
Control	-	7	7	-	63.00	50.30
Test	2	5	1	30.00	57.20	5.00
CULT						
Control	1	4	9	1.20	64.00	135.40
Test	4	6	2	50.00	113.60	10.00
DISC						
Control	-	2	1	-	32.00	25.00
Test	-	2	-	-	40.00	-
FERT						
Control	1	4	3	4.00	64.00	44.80
Test	4	1	-	52.00	15.00	-
HARR						
Control	-	-	3	-	-	66.00
Test	-	-	-	-	-	-
HAUL						
Control	-	-	-	-	-	-
Test	-	1	-	-	12.00	-
MOLD						
Control	-	2	3	-	16.00	25.10
Test	2	-	-	15.00	-	-
OIL						
Control	-	1	-	-	12.00	-
Test	-	-	-	-	-	-
PACK						
Control	-	-	1	-	-	3.80
Test	-	-	-	-	-	-
PLANT						
Control	1	5	4	1.20	75.00	61.80
Test	9	9	2	117.00	131.30	10.00

Table II.6 Operation Coverage on Wheat Crops in the Pittock Watershed (Cont'd)

	# of Operations			Acres Covered		
	1989	1990	1991	1989	1990	1991
RAKE						
Control	-	-	1	-	-	11.20
Test	-	-	-	-	-	-
SPRAY						
Control	1	2	5	4.00	27.00	47.60
Test	1	3	1	7.00	33.20	5.00
SPREA						
Control	-	-	-	-	-	-
Test	2	-	-	0.00	-	-
STONE						
Control	-	-	2	-	-	32.00
Test	1	-	-	15.00	-	-
TILL						
Control	-	-	-	-	-	-
Test	-	1	-	-	22.00	-
WIND						
Control	-	-	-	-	-	-
Test	-	1	-	-	12.00	-

Table II.7 Operation Coverage on Corn Crops in the Essex Watershed

	# of Operations			Acres Covered		
	1989	1990	1991	1989	1990	1991
CHOP						
Control	-	-	-	-	-	-
Test	1	-	-	29.00	-	-
COMB						
Control	1	2	-	10.80	10.00	-
Test	3	4	7	72.00	72.00	55.40
CULT						
Control	3	8	-	29.70	291.00	-
Test	6	2	5	176.00	72.00	106.50
DISC						
Control	-	-	-	-	-	-
Test	2	1	1	64.00	72.00	49.00
FERT						
Control	1	1	-	18.00	30.00	-
Test	3	1	5	78.00	72.00	42.50
FURR						
Control	-	1	-	-	10.00	-
Test	1	-	-	43.00	-	-
HARRO						
Control	-	-	-	-	-	-
Test	-	-	1	-	-	2.50
HAUL						
Control	-	2	-	-	10.00	-
Test	2	-	-	35.00	-	-
LEVEL						
Control	-	-	-	-	-	-
Test	1	-	-	6.00	-	-
MOLD						
Control	1	4	-	18.00	40.00	-
Test	2	-	-	49.00	-	-
PICK						
Control	1	-	-	7.20	-	-
Test	1	-	4	6.00	-	35.00
PLANT						
Control	1	4	-	18.00	40.00	-
Test	3	2	5	78.00	72.00	91.50

Table II.7 **Operation Coverage on Corn Crops in the Essex Watershed (Cont'd)**

	# of Operations			Acres Covered		
	1989	1990	1991	1989	1990	1991
RHOE						
Control	1	1	-	18.00	60.00	-
Test	-	-	-	-	-	-
RCULT						
Control	-	1	-	-	28.00	-
Test	-	-	-	-	-	-
SPRAY						
Control	1	3	-	18.00	18.00	68.00
Test	4	1	10	158.00	36.00	164.00

Table II.8 Operation Coverage on Soybean Crops in the Essex Watershed

	# of Operations			Acres Covered		
	1989	1990	1991	1989	1990	1991
BIN						
Control	-	1	-	-	5.00	-
Test	-	-	-	-	-	-
BREAK						
Control	-	-	-	-	-	-
Test	-	1	-	-	24.00	-
CHIS						
Control	-	-	-	-	-	-
Test	1	4	10	24.00	62.80	130.90
CHOP						
Control	-	-	-	-	-	-
Test	-	3	-	-	30.20	-
COMB						
Control	7	3	2	76.00	48.00	55.00
Test	12	17	18	275.00	332.00	316.70
CULT						
Control	1	10	2	10.00	271.00	105.00
Test	22	23	11	589.40	493.50	336.00
DISC						
Control	3	-	5	66.00	-	118.00
Test	13	12	7	211.40	234.60	210.40
FERT						
Control	-	2	-	-	32.00	-
Test	7	3	5	172.60	82.00	124.00
FILL						
Control	-	-	-	-	-	-
Test	-	3	-	-	92.00	-
FURR						
Control	-	-	-	-	-	-
Test	9	9	4	247.00	258.00	76.50
HAUL						
Control	3	1	-	38.00	5.00	-
Test	1	2	1	24.00	7200	29.00
HOE						
Control	-	-	-	-	-	-
Test	16	-	-	122.00	-	-

Table II.8 Operation Coverage on Soybean Crops in the Essex Watershed (Cont'd)

	# of Operations			Acres Covered		
	1989	1990	1991	1989	1990	1991
LEVEL						
Control	-	-	-	-	-	-
Test	1	-	-	18.00	-	-
MOLD						
Control	5	7	1	61.40	103.20	25.00
Test	7	10	8	111.00	214.80	90.10
PACK						
Control	-	-	2	-	-	60.00
Test	1	1	1	24.00	18.00	18.00
PLANT						
Control	2	7	2	38.00	95.00	54.00
Test	21	25	18	476.20	407.20	381.60
RCULT						
Control	-	1	-	-	14.00	-
Test	-	1	-	-	29.00	-
RHOE						
Control	-	1	1	-	14.00	30.00
Test	2	3	-	49.00	56.00	-
SAVER						
Control	-	-	-	-	-	-
Test	-	1	-	-	29.00	-
SPRAY						
Control	1	9	4	5.00	116.00	114.00
Test	10	26	19	206.60	357.80	339.80
SPRIN						
Control	-	-	2	-	-	58.00
Test	-	-	2	-	-	-
STONE						
Control	-	-	-	-	-	-
Test	2	-	-	28.80	-	-
TICK						
Control	-	-	-	-	-	-
Test	1	-	-	24.00	-	-

Table 11.9 Operation Coverage on Wheat Crops in the Essex Watershed

	# of Operations			Acres Covered		
	1989	1990	1991	1989	1990	1991
CHOP						
Control	-	-	-	-	-	-
Test	-	2	-	-	24.00	
COMB						
Control	11	-	-	111.90	-	-
Test	-	3	-	-	31.00	-
CULT						
Control	1	-	-	30.00	-	-
Test	-	1	-	-	24.00	-
DISC						
Control	3	-	-	88.00	-	-
Test	-	-	-	-	-	-
FERT						
Control	4	-	-	119.00	-	-
Test	-	3	-	-	55.00	-
FURR						
Control	-	-	-	-	-	-
Test	-	2	-	-	31.00	-
PLANT						
Control	5	-	-	119.00	-	-
Test	-	2	-	-	31.00	-

APPENDIX III

CROP BUDGETS
BASED ON ALL AVAILABLE DATA
FROM THE KETTLE WATERSHED

Kettle Creek – Corn Following Corn (1989–91)

Comparison of Average Annual Production Costs and Net Returns for Alternative Tillage Practices (Dollars/Hectare)

	AVERAGE CORN – 1989 – 91					
	Conventional			Conservation		
	Lower	Mid	Upper	Lower	Mid	Upper
Cost of Conducting Operations: (Includes machinery and custom costs only)						
Field Preparation	40.33	53.05	65.77	65.06	84.37	103.69
Planting	12.32	16.23	20.14	10.61	17.49	24.36
Growing	6.17	13.86	21.55	10.40	17.86	25.31
Harvesting	18.86	29.76	40.66	10.60	26.81	43.02
Subtotal:	77.69	112.91	148.12	96.68	146.53	196.38
Material Costs (MA):						
Seed	52.48	71.98	91.49	60.13	68.10	76.08
Fertilizer	70.25	101.12	131.99	107.18	128.20	149.22
Herbicide	53.38	70.01	86.65	68.06	83.00	97.95
Insecticide	13.53	23.45	33.37	19.98	38.59	57.20
Subtotal:	189.63	266.56	343.49	255.35	317.89	380.44
Fuel Costs (FC)	30.57	36.05	41.54	39.13	42.98	46.84
Labour Costs/Hour (TC)	46.33	54.89	63.45	64.80	70.19	75.58
TOTAL COST (TC):	344.22	470.41	596.61	455.95	577.60	699.24
Total Hours (per hectare)	5.79	6.86	7.93	8.10	8.77	9.45
Yield (mt/hectare)	5.69	6.45	7.20	7.19	7.97	8.74
Crop Price ($/mt)	109.00	109.00	109.00	109.00	109.00	109.00
TOTAL REVENUE:	620.70	702.69	784.69	783.89	868.24	952.59
Margin:						
Revenue – MA	431.07	436.13	441.19	528.55	550.35	572.16
Revenue – TC	276.48	232.28	188.08	327.94	290.65	253.35
(Revenue – TC)/Total Hours	47.74	33.85	23.72	40.49	33.13	26.82

Kettle Creek – Corn Following Soybeans (1989 – 91)

Comparison of Average Annual Production Costs and Net Returns for Alternative Tillage Practices (Dollars/Hectare)

	AVERAGE CORN – 1989 – 91					
	Conventional			Conservation		
	Lower	Mid	Upper	Lower	Mid	Upper
Cost of Conducting Operations: (Includes machinery and custom costs only)						
Field Preparation	42.61	59.79	76.97	50.81	66.54	82.28
Planting	17.57	19.70	21.84	14.12	27.16	40.19
Growing	23.00	28.58	34.16	1.31	7.60	13.88
Harvesting	21.77	49.42	77.08	3.91	11.52	19.12
Subtotal:	104.95	157.50	210.04	70.14	112.81	155.48
Material Costs (MA):						
Seed	47.24	60.83	74.42	63.94	69.49	75.05
Fertilizer	81.12	110.23	139.33	124.13	156.61	189.08
Herbicide	68.20	78.01	87.83	50.92	67.54	84.16
Insecticide	0.00	0.00	0.00	5.90	14.23	22.57
Subtotal:	196.56	249.07	301.58	244.88	307.88	370.87
Fuel Costs (FC)	19.58	26.86	34.15	24.85	28.34	31.84
Labour Costs/Hour (TC)	35.13	45.96	56.78	39.32	47.32	55.33
TOTAL COST (TC):	356.23	479.39	602.55	379.19	496.35	613.52
Total Hours (per hectare)	4.39	5.74	7.10	4.91	5.92	6.92
Yield (mt/hectare)	6.61	8.31	10.01	6.78	8.80	10.82
Crop Price ($/mt)	109.00	109.00	109.00	109.00	109.00	109.00
TOTAL REVENUE:	720.71	906.14	1091.57	739.19	959.45	1179.70
Margin:						
Revenue – MA	524.15	657.07	790.00	494.31	651.57	808.83
Revenue – TC	364.49	426.76	489.03	360.00	463.09	566.19
(Revenue – TC)/Total Hours	82.99	74.29	68.90	73.25	78.29	81.87

Kettle Creek – Corn Following Wheat (1989–91)

Comparison of Average Annual Production Costs and Net Returns for Alternative Tillage Practices (Dollars/Hectare)

	AVERAGE CORN – 1989 – 91					
	Conventional			Conservation		
	Lower	Mid	Upper	Lower	Mid	Upper
Cost of Conducting Operations: (Includes machinery and custom costs only)						
Field Preparation	39.69	72.19	104.69	36.18	81.07	125.97
Planting	8.05	13.58	19.11	5.13	10.94	16.75
Growing	11.27	16.04	20.81	19.39	28.43	37.47
Harvesting	15.83	36.15	56.47	20.29	41.48	62.66
Subtotal:	74.83	137.96	201.09	80.98	161.92	242.86
Material Costs (MA):						
Seed	69.24	72.75	76.26	62.75	83.66	104.56
Fertilizer	120.57	155.33	190.10	78.73	112.17	145.62
Herbicide	62.42	76.33	90.24	53.15	83.40	113.64
Insecticide	0.02	5.67	11.33	1.24	4.40	7.57
Subtotal:	252.24	310.08	367.93	195.66	283.63	371.40
Fuel Costs (FC)	38.21	44.58	50.95	32.97	43.39	53.80
Labour Costs/Hour (TC)	57.69	70.74	83.79	58.99	76.11	93.22
TOTAL COST (TC):	422.97	563.36	703.75	368.81	565.05	761.28
Total Hours (per hectare)	7.21	8.84	10.47	7.37	9.51	11.65
Yield (mt/hectare)	3.70	5.13	6.56	5.24	6.40	7.56
Crop Price ($/mt)	109.00	109.00	109.00	109.00	109.00	109.00
TOTAL REVENUE:	403.33	559.02	714.71	570.78	697.59	824.40
Margin:						
Revenue – MA	151.09	248.94	346.79	374.92	413.96	452.99
Revenue – TC	–19.64	–4.34	10.96	201.97	132.54	63.11
(Revenue – TC)/Total Hours	–2.72	–0.49	1.05	27.39	13.93	5.42

Kettle Creek – Soybeans Following Corn (1989–91)

Comparison of Average Annual Production Costs and Net Returns for Alternative Tillage Practices (Dollars/Hectare)

	SOYBEANS – 1989–91					
	Conventional			Conservation		
	Lower	Mid	Upper	Lower	Mid	Upper
Cost of Conducting Operations: (Includes machinery and custom costs only)						
Field Preparation	58.61	87.78	116.95	50.25	74.87	99.50
Planting	6.45	12.35	18.25	8.47	13.02	17.56
Growing	6.81	12.14	17.48	3.96	9.24	14.53
Harvesting	17.45	42.86	68.27	22.83	32.98	43.13
Subtotal:	89.32	155.14	220.95	85.50	130.12	174.73
Material Costs (MA):						
Seed	193.37	300.93	408.49	178.37	225.10	271.84
Fertilizer	14.22	30.61	47.01	10.99	24.22	37.46
Herbicide	30.66	53.48	76.30	64.68	86.29	107.91
Insecticide	0.00	0.00	0.00	0.00	1.54	3.66
Subtotal:	238.25	385.02	531.80	254.03	337.16	420.87
Fuel Costs (FC)	27.23	37.41	47.60	25.55	31.88	38.21
Labour Costs/Hour (TC)	44.38	57.60	70.82	38.12	47.77	57.41
TOTAL COST (TC):	399.18	635.17	871.17	403.21	546.92	691.22
Total Hours (per hectare)	5.55	7.20	8.85	4.77	5.97	7.18
Yield (mt/hectare)	1.76	2.14	2.53	1.65	1.95	2.24
Crop Price ($/mt)	231.33	231.33	231.33	231.33	231.33	231.33
TOTAL REVENUE:	407.32	495.89	584.47	382.65	450.83	519.02
Margin:						
Revenue – MA	169.07	110.87	52.67	128.62	113.67	98.15
Revenue – TC	8.15	–139.28	–286.70	–20.55	–96.09	–172.20
(Revenue – TC)/Total Hours	1.47	–19.34	–32.39	–4.31	–16.09	–24.00

Kettle Creek – Soybeans Following Soybeans (1989–91)

Comparison of Average Annual Production Costs and Net Returns for Alternative Tillage Practices (Dollars/Hectare)

	AVERAGE SOYBEANS – 1989–91					
	Conventional			Conservation		
	Lower	Mid	Upper	Lower	Mid	Upper
Cost of Conducting Operations: (Includes machinery and custom costs only)						
Field Preparation	4.20	106.13	208.06	20.61	58.79	96.98
Planting	3.44	20.89	38.34	7.37	14.27	21.17
Growing	0.00	1.66	5.06	0.00	8.87	20.49
Harvesting	25.70	54.46	83.22	47.64	65.11	82.57
Subtotal:	33.34	183.14	334.68	75.62	147.04	221.21
Material Costs (MA):						
Seed	61.64	199.58	337.53	258.10	286.53	314.96
Fertilizer	7.90	30.72	53.54	9.21	23.91	38.61
Herbicide	4.34	30.02	55.70	38.61	76.07	113.53
Insecticide	0.00	1.23	3.75	0.00	0.77	2.14
Subtotal:	73.88	261.56	450.51	305.92	387.27	469.23
Fuel Costs (FC)	15.92	36.46	57.01	19.91	27.21	34.52
Labour Costs/Hour (TC)	16.29	42.90	69.51	32.18	45.50	58.82
TOTAL COST (TC):	139.42	524.06	911.70	433.62	607.03	783.78
Total Hours (per hectare)	2.04	5.36	8.69	4.02	5.69	7.35
Yield (mt/hectare)	2.15	2.40	2.66	1.52	2.59	3.66
Crop Price ($/mt)	231.33	231.33	231.33	231.33	231.33	231.33
TOTAL REVENUE:	498.09	556.23	614.37	352.39	599.13	845.87
Margin:						
Revenue – MA	424.21	294.67	163.86	46.47	211.86	376.64
Revenue – TC	358.67	32.17	–297.33	–81.23	–7.89	62.09
(Revenue – TC)/Total Hours	176.18	6.00	–34.22	–20.19	–1.39	8.44

Kettle Creek – Soybeans Following Wheat (1989–91)

Comparison of Average Annual Production Costs and Net Returns for Alternative Tillage Practices (Dollars/Hectare)

	SOYBEANS – 1989–91					
	Conventional			Conservation		
	Lower	Mid	Upper	Lower	Mid	Upper
Cost of Conducting Operations: (Includes machinery and custom costs only)						
Field Preparation	99.04	136.36	173.68	28.66	53.77	78.88
Planting	4.13	4.57	5.01	8.16	10.94	13.73
Growing	3.44	3.54	3.65	0.00	1.37	3.11
Harvesting	70.19	70.20	70.20	28.32	47.77	67.22
Subtotal:	176.81	214.67	252.54	65.14	113.85	162.94
Material Costs (MA):						
Seed	57.39	57.39	57.39	180.99	342.11	503.24
Fertilizer	41.92	41.92	41.92	0.00	8.80	20.37
Herbicide	102.41	102.41	102.41	24.35	115.79	207.23
Insecticide	0.00	0.00	0.00	0.00	0.00	0.00
Subtotal:	201.71	201.72	201.72	205.34	466.71	730.84
Fuel Costs (FC)	17.28	37.99	58.70	23.86	33.16	42.45
Labour Costs/Hour (TC)	52.81	60.49	68.17	40.58	53.10	65.62
TOTAL COST (TC):	448.61	514.87	581.12	334.92	666.81	1001.85
Total Hours (per hectare)	6.60	7.56	8.52	5.07	6.64	8.20
Yield (mt/hectare)	2.15	2.15	2.15	1.49	2.53	3.56
Crop Price ($/mt)	231.33	231.33	231.33	231.33	231.33	231.33
TOTAL REVENUE:	498.24	498.38	498.52	345.79	584.63	823.47
Margin:						
Revenue – MA	296.53	296.67	296.80	140.45	117.92	92.62
Revenue – TC	49.63	–16.49	–82.60	10.87	–82.18	–178.38
(Revenue – TC)/Total Hours	7.52	–2.18	–9.69	2.14	–12.38	–21.75

Kettle Creek – Wheat Following Soybeans (Avg 1989 – 91)

Comparison of Average Annual Production Costs and Net Returns for Alternative Tillage Practices (Dollars/Hectare)

	AVERAGE WHEAT – 1989 – 91					
	Conventional			Conservation		
	Lower	Mid	Upper	Lower	Mid	Upper
Cost of Conducting Operations: (Includes machinery and custom costs only)						
Field Preparation	0.00	31.81	70.89	0.00	5.06	11.08
Planting	3.50	11.37	19.24	9.21	16.34	23.47
Growing	0.00	8.27	18.78	5.63	9.13	12.63
Harvesting	0.00	22.89	52.76	22.30	46.26	70.21
Subtotal:	3.51	74.34	161.67	37.15	76.79	117.40
Material Costs (MA):						
Seed	1.56	27.99	54.42	26.46	37.78	49.11
Fertilizer	0.00	44.28	88.69	45.74	60.11	74.48
Herbicide	0.00	0.00	0.00	0.00	0.30	0.82
Insecticide	0.00	0.00	0.00	0.00	0.00	0.00
Subtotal:	1.56	72.26	143.10	72.20	98.20	124.41
Fuel Costs (FC)	6.21	18.20	30.20	18.56	24.38	30.19
Labour Costs/Hour (TC)	3.09	24.55	46.01	19.99	27.04	34.09
TOTAL COST (TC):	14.37	189.36	380.98	147.89	226.40	306.09
Total Hours (per hectare)	0.39	3.07	5.75	2.50	3.38	4.26
Yield (mt/hectare)	1.56	3.06	4.57	4.31	5.36	6.41
Crop Price ($/mt)	131.67	131.67	131.67	131.67	131.67	131.67
TOTAL REVENUE:	205.10	403.50	601.90	567.03	705.79	844.55
Margin:						
Revenue – MA	203.54	331.23	458.79	494.83	607.59	720.13
Revenue – TC	190.73	214.14	220.91	419.14	479.38	538.46
(Revenue – TC)/Total Hours	493.72	69.77	38.41	167.76	141.84	126.37

APPENDIX IV

CROP BUDGETS BASED ON RELIABLE/HIGH ADOPTION DATA FROM WATERSHEDS

TABLE IV.1 Per Acre Yield, Costs, and Time Requirements, Corn Following Corn Crops in the Kettle Watershed

			yield	prep	plant	grow	harv	seed	fert	herb	inse	fuel	[illegible]
	C89	T	3.33	7.86	11.58	17.12	11.40	11.90	17.47	38.28	19.03	17.02	[illegible]
	C90	T	3.07	38.33	9.05	21.58	11.40	29.25	77.28	48.20	16.94	19.45	4.10
	C90	T	2.48	37.81	9.05	20.06	7.92	29.25	56.85	42.38	16.76	20.44	[illegible]
	C91	T	2.21	1.75	7.79	3.68	5.58	30.83	11.02	41.24	0.00	9.82	[illegible]
	C91	C	2.95	24.64	6.79	19.67	4.01	31.11	87.70	52.60	0.00	14.72	3.54
	C89	C	3.63	30.53	6.76	3.59	6.38	56.68	26.10	28.06	12.29	15.28	[illegible]
	C91	C	2.80	21.89	6.79	0.00	4.53	31.11	31.30	39.15	0.00	10.95	[illegible]
	C91	C	2.16	3.42	0.49	1.58	12.92	14.10	9.73	16.66	3.37	8.67	1.40
	C90	C	2.25	21.10	5.94	13.94	12.92	29.25	61.27	30.87	0.00	20.24	3.47
	C91	C	2.16	33.67	7.72	6.93	14.25	31.50	63.35	25.62	14.12	12.72	[illegible]
TEST	mean		2.77	21.44	9.37	15.61	9.07	25.31	40.66	42.52	13.18	16.68	3.49
	standard dev		0.447	16.771	1.378	7.073	2.468	7.767	27.475	3.604	7.663	4.153	0.706
CONTROL	mean		2.66	22.54	5.75	7.62	9.17	32.29	46.58	32.16	4.96	13.76	[illegible]
	standard dev		0.535	9.661	2.409	7.028	4.279	12.506	26.454	11.316	5.971	3.654	0.776

Notes: 1) Yield in Metric Tons Per Acre
2) Costs in Dollars Per Acre
3) Time in Hours Per Acre

TABLE IV.2 Per Acre Yield, Costs, and Time Requirements, Corn Following Corn Crops in the Pittock Watershed

			yield	prep	plant	grow	harv	seed	fert	herb	inse	fuel	time
	C89	T	3.10	26.22	2.45	12.05	5.82	31.38	74.22	60.55	0.00	16.88	3.05
	C89	T	1.11	28.38	2.16	8.85	11.27	27.63	71.06	44.42	10.43	18.40	3.54
	C90	T	3.47	40.21	8.87	9.54	14.88	28.21	52.57	18.09	19.28	19.12	2.76
	C90	T	3.26	37.06	3.94	12.97	8.24	30.28	57.57	31.67	0.00	23.28	3.79
	C91	T	4.52	29.14	14.98	9.93	16.17	35.10	51.35	26.82	0.00	24.46	3.56
	C89	T	3.35	44.35	8.87	1.58	9.30	29.25	36.46	26.16	26.08	16.01	3.09
	C90	T	3.06	33.20	2.19	1.86	6.23	27.00	19.39	29.53	0.00	20.83	3.06
	C91	T	3.80	37.68	8.87	12.58	13.02	29.65	50.09	24.81	17.35	13.22	2.71
	C89	T	2.85	86.02	13.75	5.00	58.31	33.33	28.33	35.07	12.52	23.92	3.90
	C89	C	1.04	13.65	2.35	13.57	8.63	27.00	80.81	12.27	12.52	20.01	3.62
	C89	C	3.31	14.36	5.53	9.12	2.66	25.74	26.13	32.10	11.39	22.68	3.73
	C90	C	2.42	14.04	4.24	15.77	5.56	30.83	41.45	45.69	0.00	25.11	4.50
	C89	C	1.21	19.35	5.53	9.17	4.09	32.18	26.13	41.24	14.24	28.47	5.05
	C90	C	2.71	30.97	4.23	4.16	4.31	31.26	32.87	22.16	0.00	24.36	4.46
	C90	C	3.07	17.87	5.53	6.33	1.11	31.34	0.00	8.83	14.60	21.11	3.18
	C89	C	3.59	13.16	4.42	2.84	3.18	27.72	26.13	22.95	11.39	20.34	3.04
	C89	C	3.05	34.55	5.57	21.73	11.40	35.94	38.60	2.81	17.85	29.85	4.33
	C91	C	1.07	14.44	6.26	12.53	5.74	27.20	24.89	51.74	11.67	25.05	4.53
	C90	C	3.12	28.86	7.45	22.11	17.58	28.63	39.08	11.03	12.34	25.59	4.13
	C90	C	3.02	25.10	4.23	4.16	7.13	29.25	32.87	35.27	0.00	23.14	3.88
	C91	C	1.22	28.34	18.96	16.50	21.38	48.61	39.97	20.97	10.80	22.92	3.95
	C89	C	3.30	31.97	6.68	15.40	22.80	35.94	38.60	2.81	17.85	24.61	4.20
	C90	C	3.68	18.23	5.53	6.33	3.70	31.34	0.00	6.73	14.60	24.12	3.86
	C90	C	3.09	23.31	7.95	20.35	11.40	28.62	39.08	11.03	12.34	22.23	3.50
	C89	C	1.50	20.01	4.64	4.27	4.85	31.11	44.60	3.37	13.60	20.56	3.37
	C91	C	3.13	21.21	15.53	4.60	6.77	55.79	51.06	26.12	29.43	24.25	4.33
	C89	C	3.30	22.37	6.68	14.04	9.50	27.69	38.60	2.81	17.85	20.83	3.53
	C90	C	1.66	24.82	7.95	20.35	5.70	28.63	39.08	11.03	12.34	15.51	3.40
TEST	mean		3.17	40.25	7.34	8.26	15.92	30.20	49.00	33.01	9.52	19.57	3.28
	standard dev		0.864	17.124	4.657	4.165	15.370	2.522	17.246	11.934	9.447	3.650	0.412
CONTROL	mean		2.55	21.93	6.80	11.75	8.29	32.37	34.73	19.52	12.36	23.20	3.92
	standard dev		0.910	6.543	3.875	6.450	6.022	7.422	16.858	15.063	6.727	3.129	0.521

Notes: 1) Yield in Metric Tons Per Acre
2) Costs in Dollars Per Acre
3) Time in Hours Per Acre

TABLE IV.3 Per Acre Yield, Costs, and Time Requirements, Soybeans Following Soybeans in the Essex Watershed

			yield	prep	plant	grow	harv	seed	fert	herb	inse	fuel	time
	S91	T	0.87	15.52	6.83	3.01	36.48	44.97	0.73	0.60	0.00	21.80	2.40
	S91	T	1.86	58.94	6.83	9.02	36.48	64.70	2.18	11.26	0.00	26.40	4.[illegible]
	S90	T	1.16	22.95	1.99	24.17	30.00	89.94	0.00	22.54	0.00	37.91	5.[illegible]
	S91	T	0.81	14.15	15.41	3.01	18.24	42.22	2.18	0.60	0.00	14.42	2.[illegible]
	S90	T	1.25	28.25	1.99	3.54	40.04	32.98	15.24	36.46	0.00	21.17	4.04
	S89	T	0.72	43.69	0.68	11.22	26.25	86.42	0.58	42.28	0.00	17.35	3.[illegible]
	S89	T	0.97	23.88	17.99	65.67	30.00	119.39	25.58	63.50	0.00	54.46	9.[illegible]
	S90	T	1.21	23.61	4.94	3.69	6.55	56.21	0.65	35.56	0.00	17.89	2.[illegible]
	S91	T	0.65	4.72	14.64	0.00	6.55	24.98	0.00	0.00	0.00	8.93	1.0[illegible]
	S89	T	1.15	5.69	3.74	2.65	6.55	37.47	0.00	29.71	0.00	14.95	1.[illegible]
	S89	T	1.14	20.48	3.74	13.34	6.55	32.66	20.87	37.14	0.00	20.72	2.[illegible]
	S90	T	1.13	22.24	5.44	3.69	6.26	14.40	0.65	10.67	0.00	15.08	2.47
	S91	C	0.49	110.52	20.09	4.44	6.55	29.98	0.83	2.68	0.00	11.19	2.[illegible]
	S91	C	0.20	16.53	5.79	4.90	1.60	22.49	0.00	11.59	0.00	5.59	1.[illegible]
	S89	C	1.09	6.94	2.17	0.00	2.58	22.04	0.00	0.00	0.00	16.72	2.00
	S90	C	1.02	25.96	14.80	0.00	20.38	26.13	0.00	21.90	0.00	11.20	2.[illegible]
	S89	C	1.16	70.18	10.56	4.04	12.46	26.13	0.00	26.32	0.00	15.29	2.[illegible]
	S90	C	1.15	57.17	14.80	0.00	20.38	29.98	0.00	21.89	0.00	21.60	2.80
TEST	mean		1.08	23.68	7.02	11.92	20.83	53.86	5.72	24.19	0.0[illegible]	22.59	3.[illegible]
	standard dev		0.304	14.485	5.538	17.422	13.203	29.634	8.853	19.152	0.000	11.864	2.0[illegible]
CONTROL	mean		0.85	47.88	11.37	2.23	10.66	26.12	0.14	14.06	0.00	13.60	2.[illegible]
	standard dev		0.368	35.698	6.000	2.244	7.708	3.152	0.311	10.052	0.000	5.039	0.4[illegible]

Notes: 1) Yield in Metric Tons Per Acre
2) Costs in Dollars Per Acre
3) Time in Hours Per Acre